
**SAMPLING AND ANALYSIS PLAN FOR
ENVIRONMENTAL MONITORING OF THE
STREAMSIDE TAILINGS OPERABLE UNIT – 2018**

Topical Report RSI-2803

prepared for

**Montana Department of Environmental Quality
Federal Superfund and Construction Bureau
1225 Cedar Street
Helena, Montana 59620**

April 2018

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by

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1.0 INTRODUCTION

This document describes a sampling and analysis plan (SAP) to guide environmental monitoring and assess the effectiveness of remedial actions that were implemented within the Streamside Tailings Operable Unit (SSTOU) of the Silver Bow Creek/Butte Area National Priorities List site in 2018 (Figure 1-1). Data will be collected to describe the effect of remedial actions in the SSTOU on multiple environmental media including surface water, instream sediment, groundwater, vadose zone water, macroinvertebrates, periphyton, fish, geomorphology, vegetation, soils, birds, and small mammals.

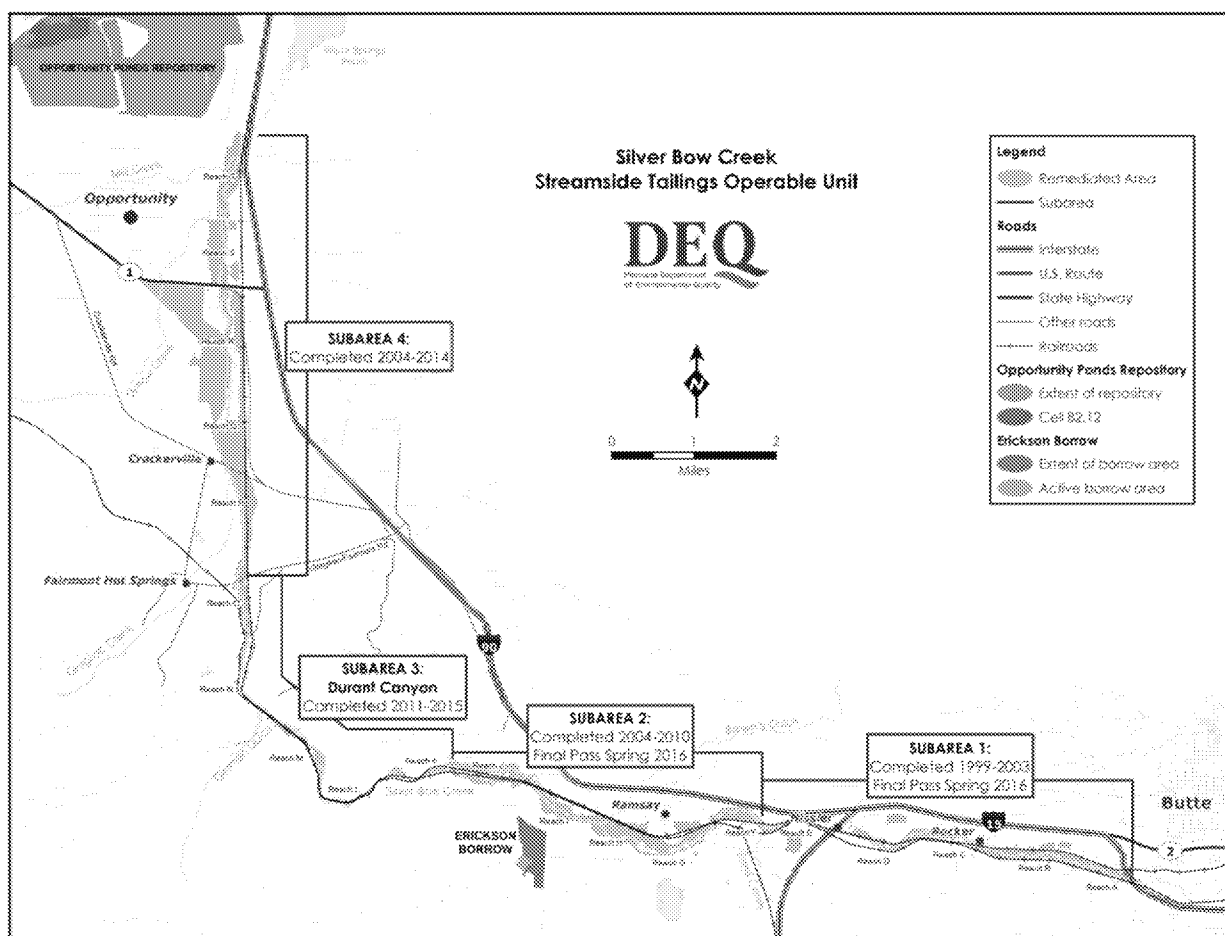


Figure 1-1. Remedial Subareas of the Streamside Tailings Operable Unit.

1.1 BACKGROUND

Silver Bow Creek extends from Butte, Montana, approximately 23 miles downstream to the Warm Springs Ponds (Figure 1-1). From the 1870s through the 1980s, Silver Bow Creek received direct and indirect inputs of waste rock, slag (i.e., smelting byproduct), mill tailings, contaminated groundwater [Chadwick et al., 1986; Luoma et al., 2005], and raw municipal sewage [Gless and

Miller, 1973]. An estimated 2 million cubic meters of tailings were deposited directly into the stream [Luoma et al., 2005]. In 1908, A major flood redistributed the waste rock and tailings downstream throughout the stream channel and floodplain [Chadwick et al., 1986]. Before remediation, streamside tailings deposits were distributed along the entire length of the stream [Brook and Moore, 1989], and localized deposits reached depths greater than 7 meters (m). Much of the floodplain was devoid of vegetation because the toxicity of floodplain tailings [Luoma et al., 2005]. Throughout the mining period (1870–1982), the stream was primarily used as a sewer for removing industrial wastes.

The copper ore deposits mined and smelted in the Butte area were found in the Butte Quartz Monzonite Formation and were dissected by dikes of porphyritic lode ore [Gammons et al., 2009]. Underground mining operations began in the area in the 1870s. Underground operations were extensive and today an estimated total of 60 vertical shafts (to depths greater than 1.6 kilometers) and approximately 16,000 kilometers (km) of workings have been abandoned [PitWatch, 2018]. In 1955, the mining effort shifted from underground to open-pit operations after initiating the Berkeley Pit mine. Open-pit mining ceased in the Berkeley Pit in 1982, and groundwater diversions were discontinued at that time. Contaminated groundwater began to accumulate in the Berkeley Pit and the underground mine workings immediately. The Berkeley Pit lake (volume = 216 million cubic meters) now contains strongly acidic (pH range = 2.3–2.5) water with extremely high metal concentrations (e.g., total recoverable copper range = 73–137 milligrams per liter [mg/L], total recoverable iron range = 507–883 mg/L) [PitWatch, 2018]. The ancestral Silver Bow Creek headwaters have been absorbed into the Berkeley and Continental Pits and Butte’s metro sewer system, including the Metro Storm Drain. Mining continues today in the Continental Pit mine for molybdenum and copper and for copper precipitate from waters in the Berkeley Pit [Montana Resources, 2018].

In November 1995, the Montana Department of Environmental Quality (DEQ) and the U.S. Environmental Protection Agency (USEPA) issued a Record of Decision (ROD) for Silver Bow Creek [DEQ and USEPA, 1995] that identified the final site remedy and the agencies’ rationale for selecting that remedy. Some aspects of the SSTOU ROD were later amended and are described in the Explanation of Significant Differences (ESD) [DEQ and USEPA, 1998]. In 1999, a consent decree settlement between the State of Montana and Atlantic Richfield Company was reached and Atlantic Richfield agreed to pay \$215 million to the state to resolve certain claims [State of Montana Versus Atlantic Richfield Company, 1999]. In the consent decree, \$80 million and interest were designated as the “SSTOU Fund” to implement the remedy for the SSTOU [State of Montana Versus Atlantic Richfield Company, 1999].

The major remedial actions that resulted from the ROD, the ESD, and the consent decree included excavating tailings and related impacted soils from the Silver Bow Creek floodplain and subsequent reconstruction of the stream channel and floodplain. The SSTOU was divided into four subareas based upon geologic and topographic features that control soil, hydrogeologic, geomorphic, surface water, ecologic, demographic, and land-use characteristics of the Operable

Unit (Figure 1-1). Each remedial subarea was further divided into remedial project reaches, which are approximately 1 mile in length.

Two features are present throughout the SSTOU, but neither is related to remedial subarea divisions: railroad bed materials and stream bed (instream) sediments. Materials that are associated with the railroad bed (in addition to native alluvium, rock and imported ballast) include mine-waste rock or low-grade ore, concentrate spills, and impacted materials consisting of nonvegetated soils, and slag. Instream sediments distribute contaminants throughout the length of the SSTOU stream channel. Instream sediments consist of tailings and soil and rock particles that have been deposited instream or are carried through the SSTOU as a result of surface water transport [DEQ and USEPA, 1995].

Remedial actions include excavating tailings and contaminated soils from the Silver Bow Creek floodplain, removing those soils to a local repository or to the Opportunity Ponds, replacing removed tailings with local fill material, native grass seeding, limited willow and shrub plantings, and complete channel reconstruction [USEPA, 2011]. Restoration actions involve various actions such as adding organic matter to the borrowed soils, plant revegetation, and aquatic habitat components [Natural Resources Damage Program, 2005].

1.2 PURPOSE

This 2018 SAP provides an annual update to previous SSTOU monitoring program SAP documents [DEQ and Natural Resources Damage Program, 2007; PBS&J, 2010; Atkins; 2011, 2012, 2013; RESPEC, 2014a, 2015, 2016, 2017a]. The purposes of each annual SSTOU SAP are to (1) identify reference benchmarks from which to evaluate the improvement of each environmental medium; (2) establish monitoring requirements for each medium; and (3) identify the monitoring locations, schedule, and parameters for each medium.

The quality assurance and quality control (QA/QC) procedures for surface water, instream sediment, groundwater, vadose zone water, macroinvertebrates, and periphyton sampling are described in a separate quality assurance project plan (QAPP) that was submitted to DEQ for comment and approval in 2014 [RESPEC, 2014b]. The project SAP will be updated annually for each environmental medium and submitted to DEQ for comments, revisions, and approval. The project QAPP will be updated as needed when changes to QA/QC protocols are proposed and approved by DEQ. No alterations of QA/QC procedures were requested by DEQ for 2018 and, therefore, no update to the QAPP is necessary. Any deviations from the SAP during the data collection or analysis phases of the monitoring program (e.g., field conditions) will be documented and reported to the DEQ project manager.

Minimum post-remedy monitoring requirements were specified in the SSTOU ROD (Table 1-1). As recommended in the SSTOU ROD, the current monitoring program has expanded beyond the minimum monitoring requirements (Table 1-1). For example, the SSTOU ROD

requires that 8 surface water sites are to be monitored (Table 1-1) but in 2018, 16 sites will be monitored.

Table 1-1. Minimum Post-Remedy Monitoring Requirements Specified in the Record of Decision for the Streamside Tailings Operable Unit [DEQ and USEPA, 1995]

| Environmental Media | Locations/Physical | Analytical Parameters | Analytes |
|----------------------------|---|---|--|
| Surface Water | SS-07, SS-10, SS-13, SS-14, SS-15, SS-16, SS-17, SS-19 | Metals (total recoverable and dissolved) | Arsenic, cadmium, copper, lead, mercury, zinc |
| | | Common ions | Calcium, magnesium, sodium, potassium, chloride, sulfate |
| | | Nutrients | Nitrate-nitrite nitrogen, phosphorus |
| | | Physical properties | Temperature, acidity (pH), oxidation-reduction potential (Eh), conductance, dissolved oxygen concentration |
| Instream Sediments | Surface water locations and at each depositional area | Metals (total) in three size fractions: < 0.063 mm, 0.063–1 mm, 1–2 mm | Arsenic, cadmium, copper, lead, mercury, zinc |
| Geomorphology | Surface water locations and at each depositional area | Physical stream parameters such as geomorphologic stability (erosion rates and locations) and bed form morphologic features | |
| Aquatic Biologic Resources | Surface water locations and at each depositional area | Macroinvertebrate diversity, abundance and aquatic health | |
| Groundwater | Near Colorado Tailings, Rocker, Silver Bow, Nissler, Ramsay Flats, Miles Crossing, Fairmont, Crackerville, Stuart, Opportunity, in-situ treatment areas and every repository location | Metals (dissolved) | Arsenic, cadmium, copper, lead, mercury, zinc |
| | | Common ions | Calcium, magnesium, sodium, potassium, chloride, sulfate |
| | | Physical properties | Temperature, acidity (pH), oxidation-reduction potential (Eh), conductance, dissolved oxygen concentration |
| Soil | Minimum of one (1) sample per 10 acres and three (3) samples per repository | Neutralization potential, sulfur fractionation, conductance, pH | |
| Vegetation | In conjunction with soil sample locations | Percent cover (total and by species), production (total and by species) | |
| Vadose Zone Water | In conjunction with groundwater sampling locations; three samples per repository location. | Metals (dissolved) | Arsenic, cadmium, copper, lead, mercury, zinc |
| | | Common ions | Calcium, magnesium, sodium, potassium, chloride, sulfate |

| | | | |
|--|--|---------------------|--|
| | | Physical properties | Temperature, acidity (pH), oxidation-reduction potential (Eh), conductance |
|--|--|---------------------|--|

mm = millimeters.

1.3 REFERENCE VALUES

The SSTOU ROD [DEQ and USEPA, 1995] specifies the final remedial action objectives and remediation standards for certain environmental media in the SSTOU. The monitoring program evaluates various other environmental media as well. For these other environmental media, reference values have been identified to allow consistent evaluation of changes in environmental conditions because of the remediation actions. Identifying these additional reference values does not replace or modify the remediation standards that were identified in the SSTOU ROD. These additional identified reference values are not intended as required performance standards for the remedy.

1.3.1 Surface Water

The SSTOU ROD specified that the final remediation goal for contaminant of concern (COC) concentrations in surface waters was to “meet the more restrictive of aquatic life or human health standards for surface water identified in DEQ Circular WQB-7, through application of I-classification requirements” [DEQ and USEPA, 1995]. After issuing the ROD, Circular WQB-7 [Montana Department of Health and Environmental Sciences, 1994] has been replaced by Circular DEQ-7 [DEQ, 2017], and standards for some of COCs have been revised. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (NCP) provide new, more stringent standards where complying with the new standard is necessary to ensure protectiveness of human health and the environment.

Although a formal decision to adopt the new, more stringent standards for the SSTOU has not been determined, this report uses the more stringent of the ROD’s Circular WQB-7 [Montana Department of Health and Environmental Services, 1994] or current Circular DEQ-7 [DEQ, 2017] standards for evaluating compliance for COCs. The most restrictive surface water standard for each COC (e.g., arsenic, cadmium, copper, lead, mercury, and zinc) is either the chronic aquatic life standard (ALS) or the human health surface water standard from either Circular WQB-7 [Montana Department of Health and Environmental Services, 1994] or Circular DEQ-7 [DEQ, 2017]. In both versions, the chronic ALS is hardness-based for cadmium, copper, lead, and zinc. Thus, the chronic ALS varies in relation to water hardness for those metals and, in all cases, becomes less restrictive as water hardness increases. The most restrictive surface water standard for each COC is depicted in Table 1-2. This report uses the current Circular DEQ-7 [DEQ, 2017] standards as reference values for metals that are not COCs (Table 1-3).

Silver Bow Creek is classified as an “I” stream under the Montana Water Quality Act [2001]. Beneficial uses for I-class streams are for “drinking, culinary, and food processing purposes after conventional treatment; bathing, swimming, and recreation; growth and propagation of fishes

and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply.” I-classification streams include the following criteria for physical properties of water:

- Dissolved oxygen concentration must not be reduced below the applicable standards given in Circular DEQ-7 (i.e., 1-day minimum = 3 mg/L [DEQ, 2017; DEQ and USEPA, 1995]).
- Hydrogen ion concentration (pH) must be maintained within the range of 6.5 to 9.5.
- Except as permitted in Article 75-5-318 [Montana Legislative Services, 1999], no increase in naturally occurring turbidity is allowed to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.
- No increase in naturally occurring temperatures is allowed to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.
- No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except as permitted in Article 75-5-318 [Montana Legislative Services, 1999]), and settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.

Table 1-2. Comparison of the Montana Surface Water Standards in July 1994 (Effective at the Time of Issuance of the Streamside Tailings Operable Unit Record of Decision) and May 2017 (Effective in 2018) for Each Contaminant of Concern

| Contaminant of Concern ^(a) | Chronic Aquatic Life Standard (mg/L) | | Human Health Surface Water Standard (mg/L) | |
|---------------------------------------|--------------------------------------|------------|--|------------|
| | MDHES [1994] | DEQ [2017] | MDHES [1994] | DEQ [2017] |
| Arsenic | 0.190 | 0.150 | 0.018 | 0.010 |
| Cadmium | 0.00113 | 0.00079 | 0.00500 | 0.00500 |
| Copper | 0.012 | 0.009 | 1.000 | 1.300 |
| Lead ^(b) | 0.0032 | 0.0032 | 0.0150 | 0.0150 |
| Mercury | 0.000012 | 0.000910 | 0.000140 | 0.000050 |
| Zinc | 0.10599 | 0.11982 | 5.00000 | 7.40000 |

Gray cells indicate the most restrictive standard.

MDHES = Montana Department of Health and Environmental Services.

(a) The aquatic life standards for cadmium, copper, lead, and zinc vary in relation to water hardness. The values displayed in this table correspond to a water hardness of 100 mg/L as CaCO₃.

(b) The chronic aquatic life standard is most restrictive for lead until hardness >338 mg/L as CaCO₃. At hardness >338 mg/L as CaCO₃, the human health surface water standard becomes more restrictive. Lead standards were the same in MDHES [1994] and DEQ [2017].

The SSTOU ROD did not specify nutrient standards for surface waters in the SSTOU. However, numeric nutrient standards have been adopted by the Montana Board of Environmental Review [DEQ, 2014]. These standards establish limits for total phosphorus and

total nitrogen for wadeable streams in the Middle Rockies Ecoregion, which includes Silver Bow Creek and tributaries in the SSTOU. The following standards apply to streams in the SSTOU between July 1 and September 30:

- Total phosphorus = 30 microgram per liter (µg/L)
- Total nitrogen = 300 µg/L.

Table 1-3. Montana Surface Water Standards for Metals That Are Not Contaminants of Concern in the Streamside Tailings Operable Unit [DEQ, 2017]^(a)

| Metal ^(b) | Aquatic Life Standard (mg/L) | | Human Health Surface Water Standard (mg/L) |
|----------------------|------------------------------|---------|--|
| | Acute | Chronic | |
| Aluminum | 0.750 | 0.087 | — |
| Antimony | — | — | 0.0056 |
| Barium | — | — | 1 |
| Beryllium | — | — | 0.004 |
| Boron | — | — | — |
| Chromium | — | — | 0.1 |
| Cobalt | — | — | — |
| Iron | — | 1.00 | — |
| Manganese | — | — | — |
| Molybdenum | — | — | — |
| Nickel | 0.469 | 0.052 | 0.100 |
| Selenium | 0.020 | 0.005 | 0.050 |
| Silver | 0.0041 | — | 0.1000 |
| Uranium | — | — | 0.03 |
| Vanadium | — | — | — |

(a) The most restrictive surface water standard for each contaminant of concern is to be used as the remediation standard for surface water in the Streamside Tailings Operable Unit [DEQ and USEPA, 1995].

(b) The aquatic life standards for nickel and silver vary in relation to water hardness. The values displayed in this table correspond to a water hardness of 100 mg/L as CaCO₃.

Circular DEQ-7 [DEQ, 2017] also specifies the following year-round ALS for total ammonia:

- Total ammonia acute ALS = 13.3 mg/L¹

¹ The total ammonia acute ALS is inversely related to pH (i.e., as pH increases, the acute ALS decreases) and it also depends on whether or not salmonids are present. The given standard assumes a pH of 7.5 and that salmonids are present. Typically, pH in the SSTOU is at least 7.5 [RESPEC, 2018] and salmonids are known to be present in the SSTOU [Lindstrom, 2013].

- Total ammonia chronic ALS = 3.97 mg/L².

In addition to measuring COC concentrations, non-COC metal concentrations, and nutrient concentrations, surface water field parameters will be measured including common cations and anions, total and volatile suspended sediment concentrations, stream flows, water temperatures, pH, conductivity, and turbidity. These additional data support the interpretation of water quality monitoring results and are needed to assess impairments to beneficial uses.

1.3.2 Instream Sediment

Ecological reference values for COC concentrations of instream sediment have been selected to evaluate the influence of remediation and the extent of recontamination from upstream sources. These reference values are the threshold effect concentration (TEC) and the probable effect concentration (PEC) and were selected from consensus-based sediment quality guidelines for benthic organisms [MacDonald et al., 2000]. At metal COC concentrations above the TEC, benthic organisms may be affected by that COC, and at metal COC concentrations above the PEC, benthic organisms are likely to be affected by that COC (Table 1-4).

Table 1-4. Reference Values for Contaminant of Concern Concentrations (Dry Weight) of Instream Sediments in the Streamside Tailings Operable Units

| Contaminant of Concern | Threshold of Effect Concentration (mg/kg-DW) | Probable Effect Concentration (mg/kg-DW) |
|------------------------|--|--|
| Arsenic | 9.79 | 33 |
| Cadmium | 0.99 | 4.98 |
| Copper | 31.6 | 149 |
| Lead | 35.8 | 128 |
| Mercury | 0.18 | 1.06 |
| Zinc | 121 | 459 |

Note that the TEC and PEC were described in MacDonald et al. [2000].

mg/kg = milligrams per kilograms.

DW = dry weight.

1.3.3 Groundwater

The SSTOU ROD specifies that the final remediation standards for groundwater COC concentrations are to “attain compliance with applicable Circular WQB-7 standards, federal

² The total ammonia chronic ALS is inversely related to pH and temperature and differs depending on whether or not early life stages of salmonids are present. The given standard assumes a pH of 7.5 and a temperature of 16 degrees Celsius (°C). Above 15°C, which is typical of the SSTOU during summer [RESPEC, 2018], the chronic ALS is not influenced by the presence or absence of early life-stage salmonids.

MCLs (maximum contaminant levels) and federal nonzero maximum contaminant level goals (MCLGs) for all SSTOU groundwater.” Moreover, “the groundwater levels to be attained consist of the more stringent of the MCL, any nonzero MCLG, or the WQB-7 human health standard for each parameter.” While more stringent standards promulgated after issuing the ROD have not been formally adopted as performance standards for this operable unit, this monitoring report uses the more stringent of the ROD’s Circular WQB-7 standards [MDHES, 1994] or current Circular DEQ-7 standards [DEQ, 2017] as the goals to be attained for purposes of evaluation. The most stringent of these standards for each COC is shown in Table 1-5.

Table 1-5. Comparison of the Montana Groundwater Standards in July 1994 (Effective at the Time of Issuance of the Streamside Tailings Operable Unit Record of Decision) and the Most Recent State Groundwater Standards for Each Contaminant of Concern

| Contaminant of Concern | Human Health Groundwater Standard (mg/L) | |
|------------------------|--|------------|
| | MDHES [1994] | DEQ [2017] |
| Arsenic | 0.018 | 0.010 |
| Cadmium | 0.00500 | 0.00500 |
| Copper | 1.000 | 1.300 |
| Lead | 0.0150 | 0.0150 |
| Mercury | 0.00014 | 0.000050 |
| Zinc | 5.0 | 2.0 |

Gray cells indicate the most restrictive standard.

1.3.4 Vadose Zone Water

No specific numeric concentration cleanup goals exist for vadose zone water COC concentrations in the SSTOU ROD [DEQ and USEPA, 1995]. The ROD specifies that metals and common ion concentrations are to be monitored in vadose zone water at each waste relocation repository to assess the mobility of contaminants from the repository sites to underlying groundwater or to the Silver Bow Creek floodplain down-gradient from any repositories. Only one waste repository (the Mine Waste Relocation Repository [MWRR]) has been established in the SSTOU.

1.3.5 Aquatic Biota

The SSTOU ROD does not specify specific numeric standards for aquatic biota (macro-invertebrates, periphyton, or fish). However, the SSTOU ROD does specify that macroinvertebrate diversity, abundance, and aquatic health are to be monitored (Table 1-1). The following sections describe reference values for each category of aquatic biota. These reference

values may be useful for assessing the variation of ecological integrity of biological assemblages over time.

1.3.5.1 Macroinvertebrates

Karr and Dudley [1981] recommend that a goal for pollution control efforts in water resources is for macroinvertebrate assemblages to reflect a “balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region.” One method for evaluating ecological integrity in the context of Silver Bow Creek after remedial activities will be to calculate the Montana Valley and Foothill Prairies (MVFP) bioassessment index [Bollman, 1998]. To arrive at an MVFP index score and impairment classification, each component metric value is calculated based on the taxonomic, functional, and tolerance attributes of the aquatic invertebrate assemblage, and categorical scores are assigned to each metric (Table 1-6). Metric scores are summed for a total score, which is expressed as a percentage of the maximum total score.

Table 1-6. Component Metrics and Scoring Scheme for the Aquatic Invertebrate-Based Montana Valley and Foothill Prairies Bioassessment Index [Bollman, 1998]

| Metric | Metric Score | | | |
|--------------------------|---------------|---------|----------|-----|
| | 3 | 2 | 1 | 0 |
| | Metric Values | | | |
| Ephemeroptera richness | >5 | 5–4 | 3–2 | <2 |
| Plecoptera richness | >3 | 3–2 | 1 | 0 |
| Trichoptera richness | >4 | 4–3 | 2 | <2 |
| Number of sensitive taxa | >3 | 3–2 | 1 | 0 |
| Percent filterers | 0–5 | 5.01–10 | 10.01–25 | >25 |
| Percent tolerant taxa | 0–5 | 5.01–10 | 10.01–35 | >35 |

In addition to the MVFP, two other aquatic invertebrate biotic indices may be helpful and will be calculated: the Hilsenhoff Biotic Index with tolerance values and impact thresholds that are modified for Montana fauna [McGuire, 2008] and the Metals Tolerance Index, which was developed by McGuire [2008] for the Clark Fork River watershed. Table 1-7 shows scoring criteria applied by McGuire for these metrics.

Table 1-7. Hilsenhoff Biotic Index and Metals Tolerance Index: Indices Modified and Developed by McGuire [2010] for Assessing Biological Integrity in the Clark Fork River Basin

| Biotic Index | “no impact” _____ “severe impact” | | | | | | |
|--------------------------------|-----------------------------------|---------|---------|---------|---------|---------|------|
| Hilsenhoff Biotic Index | <4.0 | 4.0–4.5 | 4.6–5.1 | 5.2–5.7 | 5.8–6.3 | 6.4–6.9 | >6.9 |
| Metals Tolerance Index | <4.0 | 4.0–4.9 | 5.0–5.9 | 6.0–6.9 | 7.0–7.9 | 8.0–8.9 | >8.9 |

1.3.5.2 Periphyton

Ecological integrity of periphyton assemblages in Silver Bow Creek will be assessed by sampling periphyton and determining taxa lists and counts for each diatom sample. Metric expressions of taxonomic traits, habitat preferences, and tolerance attributes will be calculated. Diatom bioindices will include the probability of sediment impairment [Teply, 2010], which is based on a discriminant function analysis of the occurrence of diatoms known to increase in abundance when deposited sediment influences community composition. This is currently the only diatom metric for which a threshold has been established by DEQ for the Middle Rockies Ecoregion.

In addition, seven diatom metrics (Table 1-8) will be combined into the Montana Mountains (MTM) bioassessment index [Bahls, 1993], which has been used previously to evaluate biological integrity in the SSTOU [Bollman et al., 2015]. The MTM overall biointegrity rating for a site is the lowest rating for any one metric calculated for that site.

Table 1-8. Component Metrics and Scoring Scheme for the Montana Mountains Diatom-Based Bioassessment Index [Bahls, 1993]

| Metric | Biological Integrity Rating | | | |
|--------------------|-----------------------------|------------|-----------|-------|
| | Excellent | Good | Fair | Poor |
| | Metric Values | | | |
| Species richness | >29 | 20–29 | 19–10 | <10 |
| Shannon diversity | >2.99 | 2.00–2.99 | 1.00–1.99 | <1.00 |
| Pollution index | >2.50 | 2.01–2.50 | 1.50–2.00 | <1.50 |
| Siltation index | <20.0 | 20.0–39.9 | 40.0–59.9 | >59.9 |
| Disturbance index | <25.0 | 25.0–49.9 | 50.0–74.9 | >74.9 |
| % Dominant species | <25.0 | 25.0–49.9 | 50.0–74.9 | >74.9 |
| % Abnormal cells | 0 | >0.0, <3.0 | 3.0–9.9 | >9.9 |

Finally, soft-bodied (i.e., nondiatom) algae will be ranked according to the estimates of relative abundances; these rankings will be used descriptively in the narrative ecological interpretations for each site.

1.3.5.3 Fish

The SSTOU ROD specifies the following remedial action objective for fish in the SSTOU: “provided that the upstream sources of Silver Bow Creek contaminants are eliminated, [remediation] . . . should attain the remedial action objective to improve the quality of Silver Bow Creek’s surface water and instream sediments to the point that Silver Bow could support the growth and propagation of fishes and associated aquatic life, one of the designated goals for an I-class stream, including a self-sustaining population of trout species.” The SSTOU ROD did not specify any fisheries’ monitoring requirements in response to the remedy. Montana Fish, Wildlife and Parks (MFWP) will conduct annual trout abundance monitoring at long-term reference sites in the SSTOU [Lindstrom, 2013]. The goals for this study and the study design details will be described by MFWP.

1.3.6 Geomorphology

The SSTOU ROD does not specify any specific performance standards for geomorphology. DEQ and the Natural Resource Damage Program (NRDP) of the Montana Department of Justice specified that the goal of remediation and restoration in the SSTOU is to provide suitable habitat to support a healthy fishery [DEQ and NRDP, 2007]. The SSTOU ROD requires that geomorphic monitoring occurs for “physical stream parameters such as geomorphologic stability (erosion rates and locations) and bedform morphologic features” at sites where surface water monitoring occurs (Table 1-1). Geomorphic monitoring should occur at each surface water site 5 and 10 years after construction is completed [DEQ and NRDP, 2007].

Using stream habitat classification methods from the USEPA’s Environmental Monitoring and Assessment Program (EMAP) [Herlihy and Lazorchak, 2001], assessments of physical conditions in Divide Creek, Montana, were made. Divide Creek was selected as a reference stream with similar geologic and hydrologic characteristics to Silver Bow Creek [Confluence Consulting, Inc., 2002a; 2002b]. The reference values for stream habitat in the Silver Bow Creek are for certain habitat characteristics (Table 1-9) to be within the range of observed conditions from the Divide Creek surveys [Confluence Consulting, Inc., 2002a; 2002b].

Table 1-9. Reference Values for Stream Habitat Characteristics in Remediated Portions of Silver Bow Creek in the Streamside Tailings Operable Unit^(a)

| Habitat Characteristic | Reference Value (Statistical Mean Within Sample Reach) (%) |
|--|--|
| Percent pools | 20–50 |
| Width-depth ratio | 8–14 |
| Cover from undercut banks | 8–20 |
| Cover from overhanging vegetation | 15–35 |
| Overstory canopy cover (measured at channel margins) | 45–65 |
| Cover provided by wood | 15–35 |

(a) Methods for quantification of habitat characteristics are described in Herlihy and Lazorchak [2001].

1.3.7 Vegetation

The following excerpt from the 2007 interim, comprehensive, long-term monitoring plan for the SSTOU [DEQ and NRDP, 2007] describes vegetation performance goals for the SSTOU.

The remediation goal for revegetation is to protect the remedy and restore remediated areas to a permanent productive condition; it must be self sustaining and self repairing. It must protect the streambanks and adjacent floodplain from erosion that would impair the remedy.

The main goal of restorative revegetation is to quicken the return of the stream and floodplain to a baseline condition. Streambank and near-stream vegetation should interact with the stream and other site factors to provide good trout habitat. This interaction is monitored in accordance with the fluvial geomorphology section of this plan. In addition, throughout the floodplain, restoration seeks to increase structural diversity (i.e., growth-form diversity) and establish a mix of physiognomic types (community structure or growth form of the dominant layers). This restores wildlife habitat for a variety of animal species. Restoration may also provide a greater array of adapted native species than remediation.

In addition to measuring compliance with these objectives, revegetation monitoring indicates how well revegetation prescriptions, methods, and materials worked. Monitoring results from different fields of the same revegetation habitat type can be combined to evaluate how different aspects of revegetation prescriptions performed, and indicate whether they should be modified for future uses. Revegetation monitoring may incorporate soil sampling if edaphic conditions are suspected of limiting revegetation success.

1.3.8 Soils

The following excerpt from the 2007 interim, comprehensive, long-term monitoring plan for the SSTOU [DEQ and NRDP, 2007] describes soil performance goals for the SSTOU.

The remediation and restoration goal for soil is to ensure that reconstructed soil is a viable growth medium, contamination levels do not seriously impair revegetation, and processes such as capillary rise of groundwater or downward percolation of run-on from outside the SST OU have not degraded the soil.

1.3.9 Birds

The SSTOU ROD does not specify remedial action objectives for birds or any monitoring requirements. Increased bird diversity in the SSTOU over time provides one indication of ecosystem recovery. Bird monitoring is conducted by DEQ to provide an additional ecological perspective to evaluate ecosystem response to the remedy in the SSTOU.

1.3.10 Small Mammals

The SSTOU ROD does not specify remedial action objectives for small mammals or any monitoring requirements. Increased small mammal diversity in the SSTOU over time provides one indication of ecosystem recovery. Small mammal monitoring is conducted by DEQ to provide an additional ecological perspective to evaluate ecosystem response to the remedy in the SSTOU.

2.0 METHODS

The purpose of performance monitoring is to collect environmental data that describe temporal and spatial variations of environmental conditions in the SSTOU. These data will provide a long-term (>20 years) record of environmental conditions in the SSTOU; this long-term record will provide data to evaluate the effect of remediation on environmental conditions in the SSTOU over time.

2.1 PROGRAM DESIGN

In 2018, major remediation will be completed in all subareas of the SSTOU (Figure 1-1). Additional smaller remedies will occur in Subareas 1 and 2 to address remnant tailings in those portions of the SSTOU [Pioneer Technical Services, Inc., 2015]. Monitoring will occur at 16 sites and 12 of these sites are on the Silver Bow Creek within the SSTOU. Surface water sampling of metal COC concentrations, nutrient concentrations, and other water quality field parameters will occur once during each calendar quarter. Stream flows will be measured at all surface water sampling sites at the time when sampling occurs. At two sites, stream flows will be determined by the U.S. Geological Survey (USGS) stream flow gages, which are colocated at the sampling site. At sites without colocated USGS gage stations, stream flows will be measured manually. Instream sediment sampling of metal COC concentrations will also occur in all calendar quarters at each surface water sampling site. Groundwater and vadose zone water will be monitored at specified sites during the second quarter (Q2) and third quarter (Q3).

Aquatic biota (macroinvertebrates and periphyton) samples will be collected during Q3 at each surface water sampling site. MFWP will monitor the abundance of fish species at specific sites during the fourth quarter (Q4) of 2018. Fish monitoring methods will be described by MFWP. Vegetation, soil, bird, and small mammal monitoring may be performed by Bighorn Environmental Sciences (Dillon, Montana). If monitoring these media is conducted, detailed methods for vegetation, soil, bird, and small mammal monitoring will be described by Bighorn Environmental Sciences.

All monitoring activities will adhere to DEQ-approved project QA/QC procedures [RESPEC, 2014b]. Laboratory analysis of analyte concentrations in surface water, sediment, groundwater, and vadose zone water samples will be provided by Energy Laboratories (Helena, Montana). Laboratory analysis of macroinvertebrate and duplicate periphyton samples will be provided by Rhithron Associates (Missoula, Montana).

2.2 MONITORING LOCATIONS

2.2.1 Surface Water, Sediment, Macroinvertebrates, Periphyton, and Geomorphology

Surface water, instream sediment, macroinvertebrates, and periphyton samples will be collected at 16 long-term monitoring sites in 2018 (Figure 2-1; Table 2-1). For sediment monitoring, two additional temporary monitoring sites located above (SS-04) and below (SLAG-01) the confluence of Silver Bow Creek and Blacktail Creek will also be monitored (Figure 2-2). Of the 16 long-term sites, 12 sites were located within the SSTOU (Figure 2-1; Table 2-1).

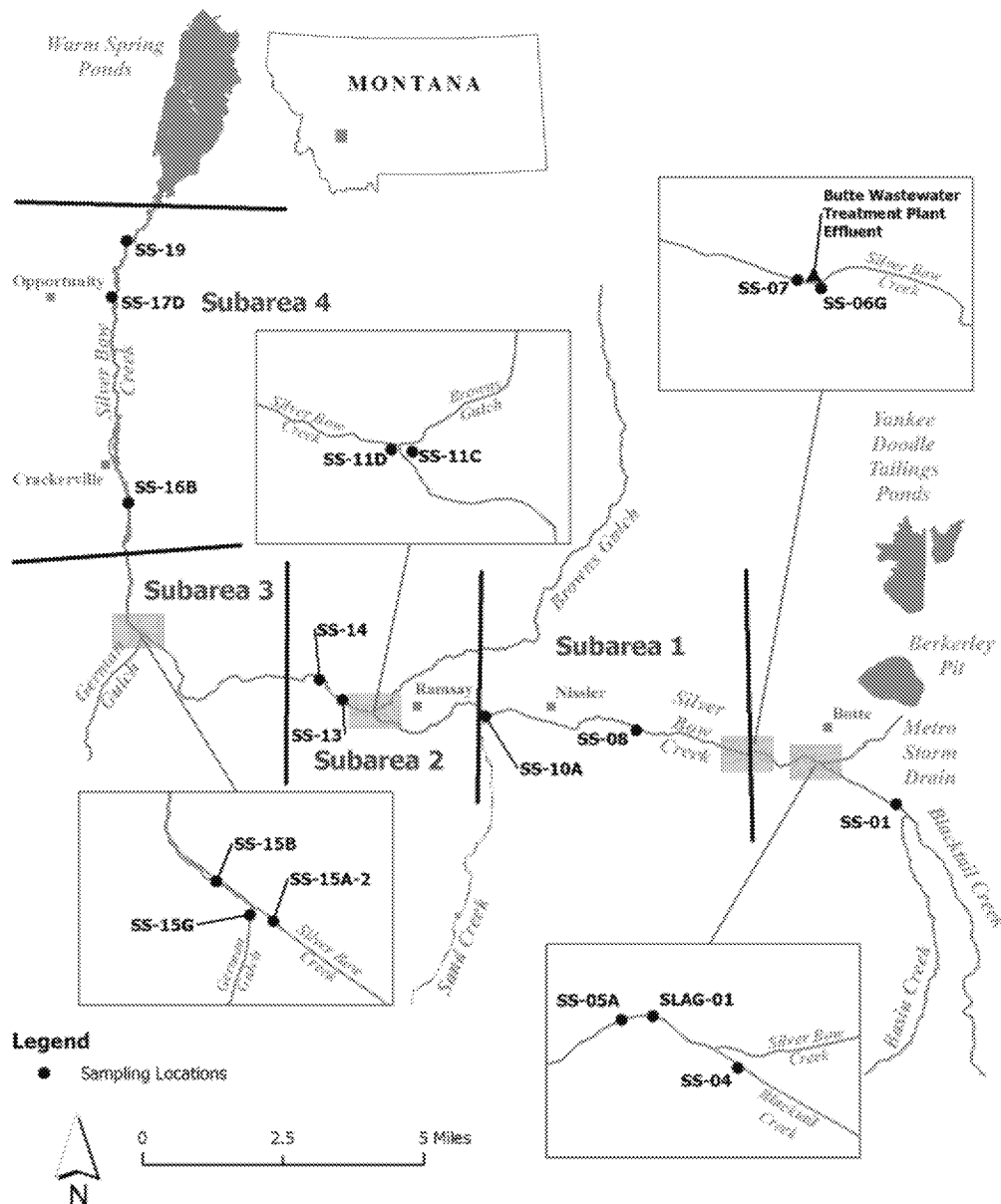


Figure 2-1. Sampling Locations for Environmental Monitoring in the Streamside Tailings Operable Unit.

Table 2-1. Surface Water, Sediment, and Aquatic Biota (Macroinvertebrate and Periphyton) Sampling Locations in the Streamside Tailings Operable Unit

| Site I.D. | Site Location | Within SSTOU | Location (GPS Coordinates, NAD 83) | |
|-----------------------|--|--------------|------------------------------------|------------|
| | | | Latitude | Longitude |
| SS-01 | Blacktail Creek at Father Sheehan Park | | 45.98532 | -112.50772 |
| SS-04 ^(a) | Blacktail Creek at Metro Storm Drain Confluence | | 45.99460 | -112.53592 |
| SLAG-01 | Silver Bow Creek in Slag Canyon | | 45.99675 | -112.54143 |
| SS-05A | Silver Bow Creek Above Butte Reduction Works | | 45.99653 | -112.54343 |
| SS-06G | Silver Bow Creek Above Butte WWTP | x | 45.99648 | -112.56316 |
| SS-07 ^(b) | Silver Bow Creek Below Butte WWTP | x | 45.99679 | -112.56470 |
| SS-08 | Silver Bow Creek at Rocker | x | 46.00167 | -112.60490 |
| SS-10A | Silver Bow Creek Above Sand Creek | x | 46.00375 | -112.66084 |
| SS-11C | Silver Bow Creek Above Browns Gulch | x | 46.00336 | -112.70172 |
| SS-11D | Silver Bow Creek Below Browns Gulch | x | 46.00342 | -112.70304 |
| SS-13 | Silver Bow Creek in Reach L | x | 46.00647 | -112.71394 |
| SS-14 | Silver Bow Creek at Miles Crossing | x | 46.01142 | -112.72270 |
| SS-15A-2 | Silver Bow Creek Above German Gulch (Alternate Site) | x | 46.02096 | -112.78802 |
| SS-15B | Silver Bow Creek Below German Gulch | x | 46.02263 | -112.79175 |
| SS-15G | German Gulch Near Confluence | | 46.02170 | -112.79029 |
| SS-16B | Silver Bow Creek in Reach P near Fairmont | x | 46.05494 | -112.79611 |
| SS-17D ^(c) | Silver Bow Creek Below Stewart Street at Opportunity | x | 46.10787 | -112.80553 |
| SS-19 | Silver Bow Creek at Frontage Road | x | 46.12250 | -112.80077 |

(a) Colocated with USGS gage 12323240.

(b) Colocated with USGS gage 12323250.

(c) Colocated with USGS gage 12323600.

The locations of the sampling sites were selected based on SSTOU ROD requirements (Table 1-1). Long-term monitoring sites that are located outside of the SSTOU were sampled to describe instream sediment conditions in portions of Silver Bow Creek and Blacktail Creek immediately upstream from the SSTOU (Sites SS-01, SS-05A, SS-06G) and in a major tributary (German Gulch) entering the Silver Bow Creek within the SSTOU (Site SS-15G) (Figure 2-1). Site SS-05A is located within Lower Area One of the Butte Priority Soils Operable Unit and historically was heavily contaminated by mining and smelting waste; therefore, Site SS-05A is not representative of background conditions. Blacktail Creek at Father Sheehan Park (Site SS-01) and German Gulch (Site SS-15G) probably best represent the background conditions outside the direct influence of mining contamination from Butte area operations.

All monitoring sites will be consistent from 2017 to 2018 with one exception: the long-term monitoring Site SS-15A (Silver Bow Creek above German Gulch) will be discontinued and replaced by an alternate site (SS-15A-2), which is located approximately 150 m upstream (Figure

2-3). This change occurred because Site SS-15A is not representative of the majority of the stream-channel condition in Subarea 3 above German Gulch. Site SS-15A is located in a short (approximately 0.3 stream km), narrow, bedrock chute with residual tailings. This narrow chute was not remediated because the low volume of floodplain tailings in that reach were determined to be too low given the tight working space and poor access for heavy equipment. All of the other streambed and floodplain portions of Subarea 3 above German Gulch (approximately 6.5 stream km) were remediated. Paired sediment samples that were collected from Site SS-15A and SS-15A-2 during all monitoring periods in 2016–2017 ($n = 8$) demonstrated that the concentrations of COCs (arsenic, cadmium, copper, lead, mercury, and zinc) were substantially higher at the unremediated site (SS-15A) compared to the remediated site (SS-15A-2) [RESPEC, 2017b; 2018]. A record of changes to the sampling sites from 2005 is provided in Appendix A.



Figure 2-2. Silver Bow Creek and Blacktail Creek Instream Sediment Sampling Locations Near the Slag Canyon (Highlighted in Yellow) and the Metro Storm Drain (i.e., Silver Bow Creek) and Blacktail Creek Confluence in Butte, Montana.

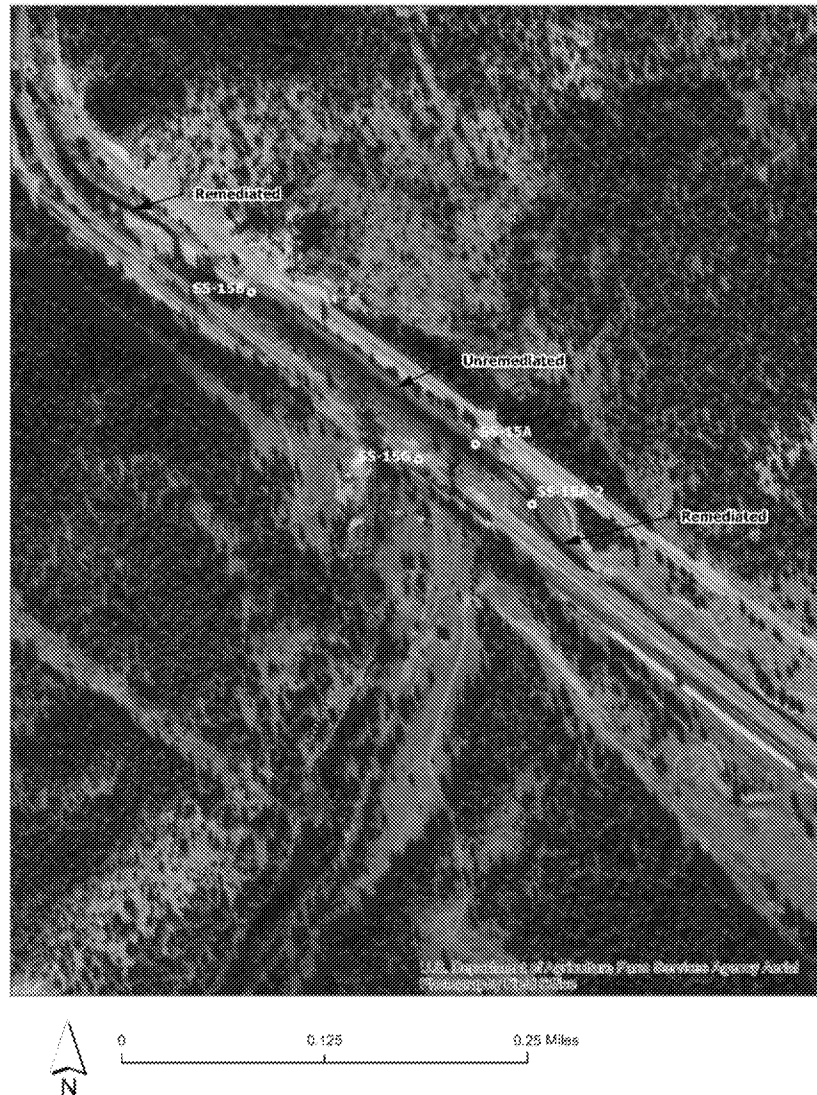


Figure 2-3. Instream Sediment Sampling Locations in the Vicinity of the German Gulch Confluence in the Streamside Tailings Operable Unit. The reach of the Silver Bow Creek stream channel (highlighted in red) was not remediated because of the limited access and relatively low estimated tailings volume.

2.2.2 Groundwater

Groundwater will be monitored at 33 wells that are distributed among 10 well clusters (Figure 2-4; Table 2-2). The groundwater-monitoring network includes nine well clusters located along the Silver Bow Creek in the SSTOU and one cluster located near the MWRR (Table 2-2). Each groundwater monitoring cluster located along the Silver Bow Creek will have a monitoring well in the floodplain on each side of the creek and a background monitoring well that is located immediately outside the floodplain. The background well for the MWRR will be located up-gradient from the MWRR. A record of changes to the groundwater-monitoring network since 2005 is provided in Appendix A.

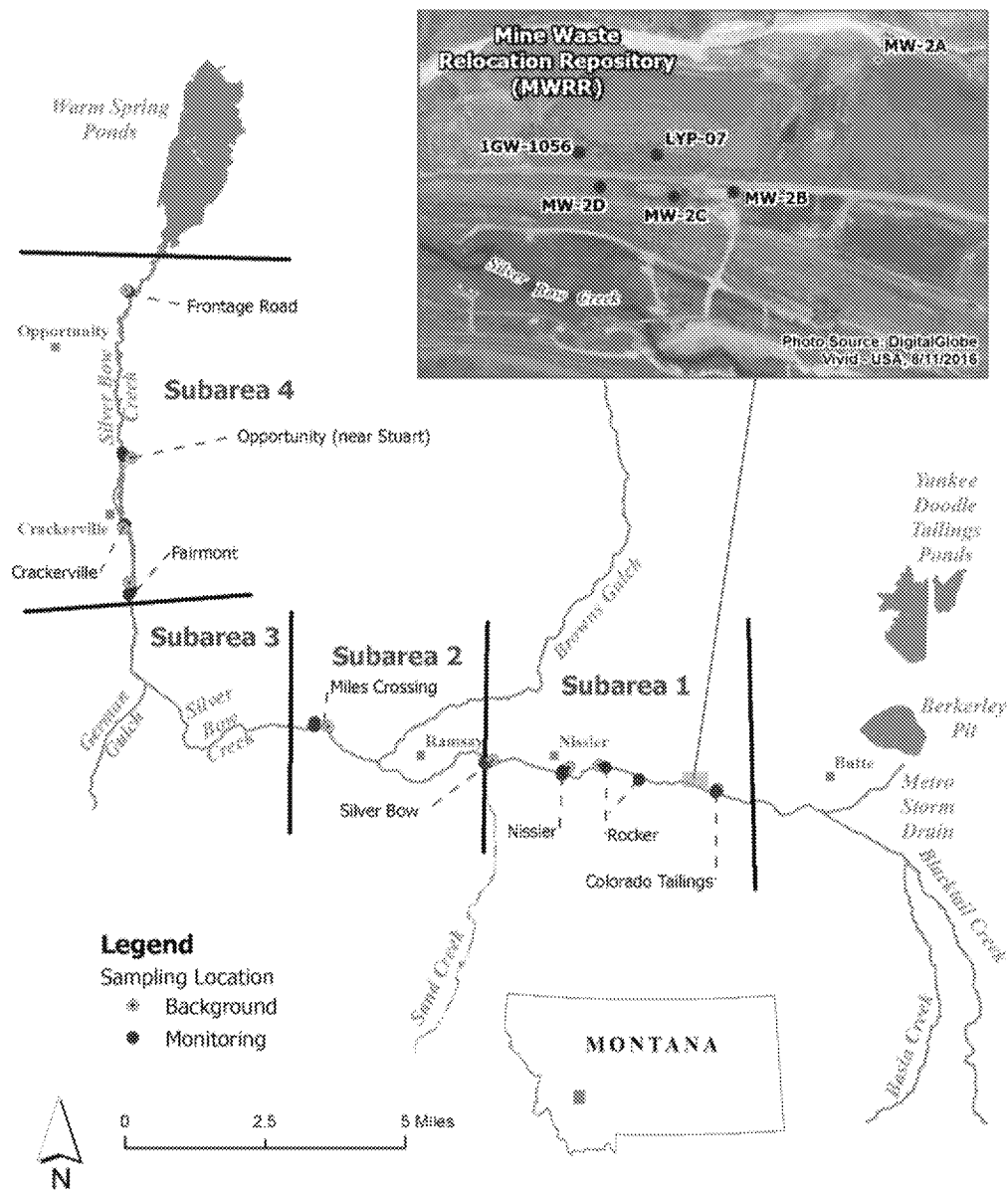


Figure 2-4. Sampling Locations for Groundwater Monitoring in the Streamside Tailings Operable Unit.

Table 2-2. Sampling Locations for Groundwater Monitoring in the Streamside Tailings Operable Unit

| Well Cluster | Well I.D. | Well Purpose | Location (GPS Coordinates, NAD 83) | |
|----------------------------------|-------------------------|--------------|---------------------------------------|------------|
| | | | Latitude | Longitude |
| Colorado Tailings | GW-1010R | Background | 45.99979 | -112.57561 |
| | GW-WG-SS ^(a) | Floodplain | 45.99940 | -112.57622 |
| | GW-WG-NS ^(b) | Floodplain | 45.99916 | -112.57624 |
| Rocker | GW-RK-BG | Background | 46.00483 | -112.62020 |
| | MW-10 | Floodplain | 46.00447 | -112.61734 |
| | MW-01 | Floodplain | 46.00155 | -112.60496 |
| Nissler | GW-1003R | Background | 46.00405 | -112.63095 |
| | 1GW-1004A | Floodplain | 46.00307 | -112.63343 |
| | P-58A | Floodplain | 46.00211 | -112.63355 |
| Silver Bow | P-39R | Floodplain | 46.00440 | -112.66235 |
| | P-37A | Floodplain | 46.00449 | -112.66112 |
| | P-114 | Background | 46.00508 | -112.65941 |
| Miles Crossing | GW-MC-NS | Floodplain | 46.01300 | -112.72600 |
| | GW-MC-SS | Floodplain | 46.01200 | -112.72600 |
| | GW-MC-BG | Background | 46.01200 | -112.72100 |
| Mine Waste Relocation Repository | 1GW-1056 | Monitoring | 46.00263 | -112.58615 |
| | LYP-07 | Monitoring | 46.00264 | -112.58483 |
| | MW-2A | Background | 46.00386 | -112.58114 |
| | MW-2B | Monitoring | 46.00223 | -112.58350 |
| | MW-2C | Monitoring | 46.00215 | -112.58451 |
| | MW-2D | Monitoring | 46.00223 | -112.58577 |
| Fairmont | GW-FM-ES | Floodplain | 46.04400 | -112.79692 |
| | GW-FM-WS | Floodplain | 46.04510 | -112.79601 |
| | GW-FM-BG | Background | 46.04711 | -112.79700 |
| Crackerville | GW-CR-ES | Floodplain | 46.06211 | -112.79942 |
| | GW-CR-WS | Floodplain | 46.06196 | -112.79980 |
| | GW-CR-BG | Background | 46.06112 | -112.79994 |
| Opportunity (near Stuart) | GW-ST-ES | Floodplain | 46.07975 | -112.80107 |
| | GW-ST-WS | Floodplain | 46.08053 | -112.80146 |
| | GW-ST-BG | Background | 46.07939 | -112.79810 |
| Frontage Road | GW-FR-ES | Floodplain | 46.12223 | -112.80167 |
| | GW-FR-WS | Floodplain | 46.12250 | -112.80225 |
| | GW-FR-BG | Background | 46.12263 | -112.80268 |

(a) Replacement well for P-06A. Well P-06A was discontinued in 2016 because of damage from frost heaving.

(b) Replacement well for GW-1052R. Well GW-1052R was discontinued in 2016 because of damage from beaver activities.

2.2.3 Vadose Zone Water

The vadose zone water will be monitored at eight lysimeters that are located nearby (Figure 2-5; Table 2-3). The MWRR lysimeter cluster will include a background monitoring lysimeter that is located up-gradient from the MWRR. A record of changes to the vadose zone monitoring network since 2005 is provided in Appendix A.

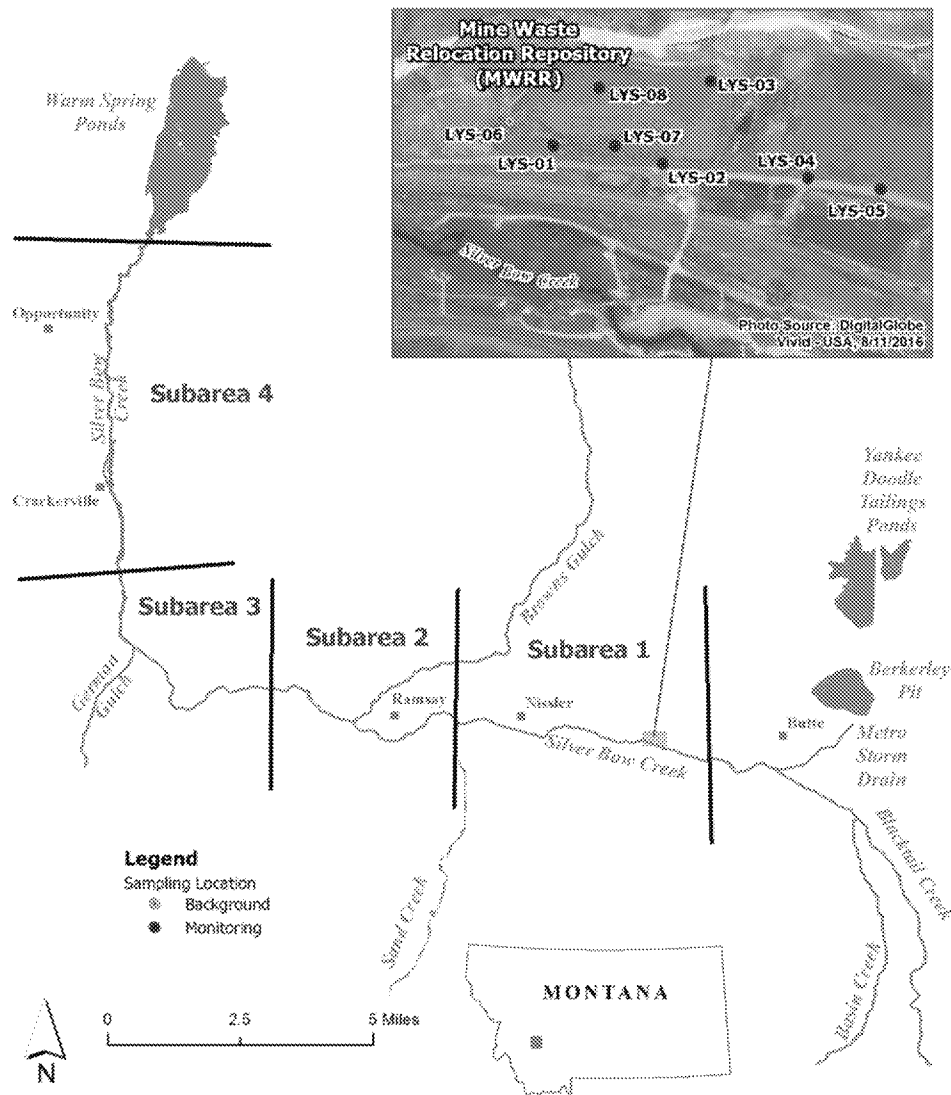


Figure 2-5. Sampling Locations for Vadose Zone Monitoring in the Streamside Tailings Operable Unit.

**Table 2-3. Sampling Locations for Vadose Zone Water Monitoring
of the Mine Waste Relocation Repository in the
Streamside Tailings Operable Unit**

| Lysimeter I.D. | Purpose | Location (GPS coordinates, NAD 83) | |
|-------------------|------------|---------------------------------------|------------|
| | | Latitude | Longitude |
| LYS-01 | Monitoring | 46.00261 | -112.58599 |
| LYS-02 | Monitoring | 46.00244 | -112.58403 |
| LYS-03 | Monitoring | 46.00349 | -112.58323 |
| LYS-04 | Monitoring | 46.00233 | -112.58141 |
| LYS-05 | Monitoring | 46.00223 | -112.58011 |
| LYS-06 | Background | 46.00289 | -112.58679 |
| LYS-07 | Monitoring | 46.00264 | -112.58489 |
| LYS-08 | Monitoring | 46.00336 | -112.58521 |

2.2.4 Geomorphology

The interim monitoring plan specified that geomorphic monitoring should occur twice after reconstruction occurs at each site at 5 and 10 years after reconstruction [DEQ and NRDP, 2007]. Based on the timeline of remedial progress in the SSTOU, geomorphic monitoring in 2018 will be required at seven sites: SS-11D, SS-13, SS-14D, SS-15A-2, SS-15B, SS-17D, and SS-19 (Table 2-4). Monitoring at Subarea 2 sites (SS-11D, SS-13, SS-14D) will represent 10-year, post-construction conditions. Monitoring at Subarea 3 and 4 sites (SS-15A-2, SS-15B, SS-17D, SS-19) will represent 5-year, post-construction conditions.

2.2.5 Fish

Fish-monitoring locations were established by MFWP before this monitoring program. Fish-monitoring locations are expected to remain the same as previous years (Figure 2-6). MFWP will provide precise locations for fisheries monitoring in consultation with DEQ.

Table 2-4. Geomorphic Monitoring Schedule for the Streamside Tailings Operable Unit (Sites Are to Be Monitored at 5-Year Intervals After Remediation Has Been Completed in Each Associated Reach) [DEQ and NRDP, 2007]^(a)

| Subarea | Reach | Site I.D. | Year Remedy Completed | Scheduled Monitoring | | Years Monitored | Due for Monitoring in 2018 |
|---------|-------|-----------|-----------------------|----------------------|---------|-----------------|----------------------------|
| | | | | 5-Year | 10-Year | | |
| 1 | A | SS-07 | 2003 | 2008 | 2013 | 2013 | |
| | B | SS-08 | 2003 | 2008 | 2013 | 2007, 2013 | |
| | E | SS-10A | 2003 | 2008 | 2013 | 2009, 2014 | |
| 2 | F | SS-10B | 2004 | 2009 | 2014 | 2009, 2014 | |
| | H | SS-11C | 2006 | 2011 | 2016 | 2011, 2016 | |
| | I | SS-11D | 2008 | 2013 | 2018 | 2012 | X |
| | | SS-13 | 2008 | 2013 | 2018 | 2014 | X |
| | J | SS-14D | 2008 | 2013 | 2018 | 2014 | X |
| 3 | M | SS-15A-2 | 2013 | 2018 | 2023 | | X |
| | M | SS-15B | 2013 | 2018 | 2023 | | X |
| 4 | P | SS-16B | 2011 | 2016 | 2021 | 2016 | |
| | T | SS-17D | 2013 | 2018 | 2023 | | X |
| | | SS-19 | 2013 | 2018 | 2023 | | X |

(a) Sites SS-01, SS-05A, SS-06G, and SS-15G shown in Figure 2-1 and Table 2-1 are monitored for other environmental media (e.g., surface water), but these sites are located outside the SSTOU. Geomorphology will not be monitored at those sites unless requested by the DEQ project managers.

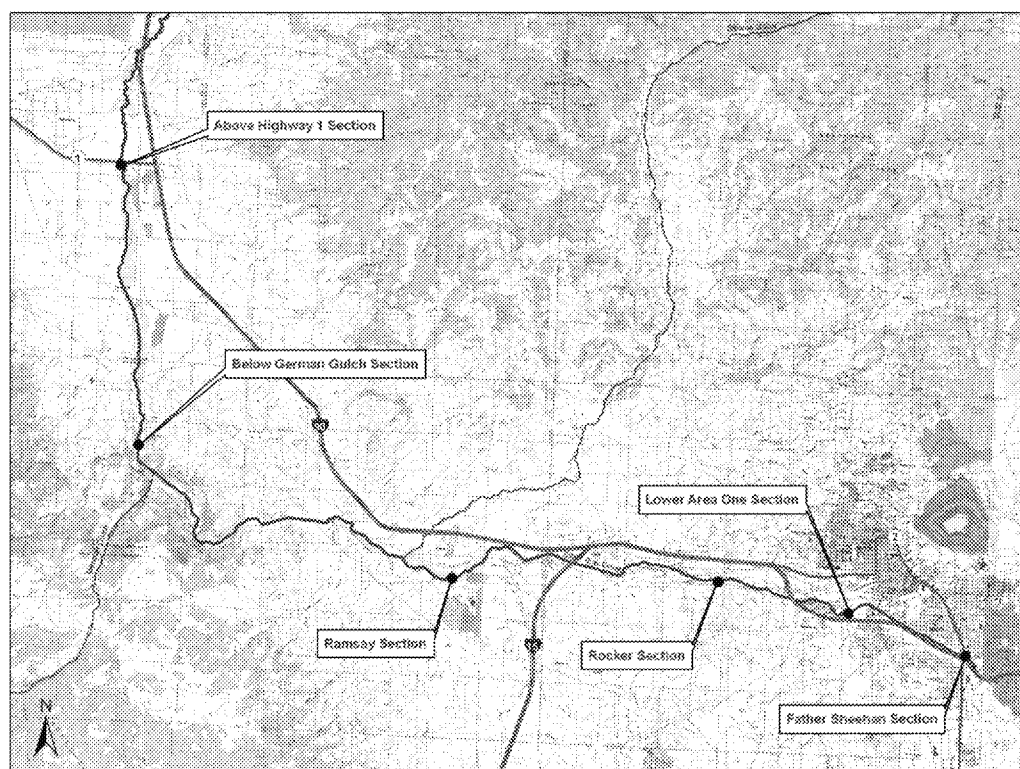


Figure 2-6. Long-Term, Fish-Sampling Sites of Montana Fish, Wildlife, and Parks [Lindstrom, 2013].

2.2.6 Vegetation, Soils, Birds, and Small Mammals

Monitoring locations for vegetation, soils, birds, and small mammals will be determined by the DEQ project managers in consultation with Bighorn Environmental Sciences.

2.3 MONITORING SCHEDULE

One monitoring event will occur during each calendar quarter. Quarterly monitoring events will occur near the end of each quarter, except during Q2. Q1 monitoring will occur in the late winter or early spring before spring snowmelt runoff. Q2 monitoring will be scheduled at approximately the peak of the spring snowmelt runoff period, usually in late May or early June. Q3 monitoring will be scheduled during late summer. Q4 monitoring will occur during the late fall (late-November to early December). Modifications to the sampling schedule because of weather or inaccessibility to sites will be made at the discretion of DEQ and RESPEC project managers. Inaccessibility because of unforeseeable field conditions during a monitoring event may necessitate relocating a site (or sites) or eliminating some sampling parameters from a particular site(s). The decision to alter or eliminate sampling parameters will be made by field crew members using their best professional judgment.

2.3.1 Surface Water, Sediment, Macroinvertebrates, and Periphyton

The monitoring schedule will differ for each environmental medium (Table 2-5). Surface water and instream sediment will be sampled at all sites during each quarterly monitoring period. Macroinvertebrate and periphyton sampling will occur in Q3.

2.3.2 Groundwater and Vadose Zone Water

Groundwater and vadose zone water will be monitored in Q2 and Q3. In Q2, groundwater and vadose zone water will be monitored only at wells (Figure 2-4; Table 2-2) and lysimeters (Figure 2-5; Table 2-3) in the MWRR cluster. In Q3, groundwater sampling will occur at all wells (Figure 2-4; Table 2-2) and lysimeters (Figure 2-5; Table 2-3). Q2 sampling will be scheduled near the peak of the spring snowmelt hydrograph, and Q3 sampling will be scheduled during the summer's base stream flow conditions.

2.3.3 Geomorphology

Geomorphology monitoring will occur in Q3.

2.3.4 Fish

MFWP has previously monitored fish in the SSTOU in Q4 during October. The schedule for fish monitoring will be determined by MFWP and DEQ.

Table 2-5. Surface Water, Instream Sediment, Macroinvertebrate, and Periphyton Sampling Schedule for Monitoring of the Streamside Tailings Operable Unit

| Site I.D. | Site Location | Sampling Event ^(a,b) | | | |
|-----------------------|--|---------------------------------|-------|-------------|-------|
| | | Q1 | Q2 | Q3 | Q4 |
| SS-01 ^(c) | Blacktail Creek at Father Sheehan Park | SW, S | SW, S | SW, S, M, P | SW, S |
| SS-04 | Blacktail Creek Above Metro Storm Drain | S | S | S | S |
| SLAG-01 | Silver Bow Creek in Slag Canyon | S | S | S | S |
| SS-05A ^(c) | Silver Bow Creek Above Butte Reduction Works | SW, S | SW, S | SW, S, M, P | SW, S |
| SS-06G ^(c) | Silver Bow Creek Above WWTP | SW, S | SW, S | SW, S, M, P | SW, S |
| SS-07 | Silver Bow Creek Below WWTP | SW, S | SW, S | SW, S, M, P | SW, S |
| SS-08 | Silver Bow Creek at Rocker | SW, S | SW, S | SW, S, M, P | SW, S |
| SS-10A | Silver Bow Creek Above Sand Creek | SW, S | SW, S | SW, S, M, P | SW, S |
| SS-11C | Silver Bow Creek ABOVE Browns Gulch | SW, S | SW, S | SW, S, M, P | SW, S |
| SS-11D | Silver Bow Creek below Browns Gulch | SW, S | SW, S | SW, S, M, P | SW, S |
| SS-13 | Silver Bow Creek in Reach L | SW, S | SW, S | SW, S, M, P | SW, S |
| SS-14D | Silver Bow Creek at Miles Crossing | SW, S | SW, S | SW, S, M, P | SW, S |
| SS-15A-2 | Silver Bow Creek Above German Gulch | SW, S | SW, S | SW, S, M, P | SW, S |
| SS-15B | Silver Bow Creek Below German Gulch | SW, S | SW, S | SW, S, M, P | SW, S |
| SS-15G ^(c) | German Gulch Near Confluence | SW, S | SW, S | SW, S, M, P | SW, S |
| SS-16B | Silver Bow Creek in Reach P near Fairmont | SW, S | SW, S | SW, S, M, P | SW, S |
| SS-17D | Silver Bow Creek Below Stewart Street at Opportunity | SW, S | SW, S | SW, S, M, P | SW, S |
| SS-19 | Silver Bow Creek at Frontage Road | SW, S | SW, S | SW, S, M, P | SW, S |

- (a) Abbreviations for monitoring categories: SW = surface water, S = sediment, M = macroinvertebrates, P = periphyton.
- (b) Abbreviations for annual sampling events: Q1 = first quarter, Q2 = second quarter, Q3 = third quarter, Q4 = fourth quarter.
- (c) Sample site is outside the boundary of the Streamside Tailings Operable Unit.

2.3.5 Vegetation, Soils, Birds, and Small Mammals

Bighorn Environmental Sciences has previously monitored vegetation, soils, birds, and small mammals in the SSTOU in Q2 or Q3. The schedule for vegetation, soils, bird, and small mammal monitoring will be determined by Bighorn Environmental Sciences and DEQ.

2.4 MONITORING PARAMETERS

2.4.1 Surface Water

Surface water samples will be analyzed for the parameters and analytes that are listed in Table 2-6.

Table 2-6. Sampling Parameters and Analytes for Surface Water Monitoring in the Streamside Tailings Operable Unit

| Parameter | Analytes |
|---|--|
| Concentrations of metal contaminants of concern (total recoverable and dissolved) | Arsenic, cadmium, copper, lead, mercury, zinc |
| Concentrations of other metals (total recoverable and dissolved) | Aluminum, antimony, barium, beryllium, boron, cobalt, chromium, iron, manganese, molybdenum, nickel, selenium, silver, uranium, vanadium |
| Nutrient concentrations | Nitrogen (total nitrogen, nitrate plus nitrite, ammonia), phosphorus (total) |
| Common ion concentrations (total) | Total alkalinity, bicarbonate alkalinity, calcium, magnesium, potassium, sodium, sulfate, chloride |
| Other physical properties | Total suspended sediment concentrations, hardness, water temperature, pH, specific conductivity, dissolved oxygen, turbidity |

2.4.2 Instream Sediment

Instream sediment samples will be analyzed for dry-weight concentrations of each of the COCs (i.e., arsenic, cadmium, copper, lead, mercury, and zinc) in each of three sediment size fractions (i.e., <0.065 mm, 0.065-1 mm, 1–2 mm).

2.4.3 Groundwater and Vadose Zone Water

Groundwater and vadose zone water samples will be analyzed for the parameters and analytes that are listed in Table 2-7.

Table 2-7. Sampling Parameters and Analytes for Groundwater Monitoring and Vadose Zone Water Monitoring in the Streamside Tailings Operable Unit

| Parameter | Analytes |
|---|--|
| Concentrations of metal contaminants of concern (dissolved) | Arsenic, cadmium, copper, lead, mercury, zinc |
| Concentrations of other metals (dissolved) | Aluminum, antimony, barium, beryllium, boron, cobalt, chromium, iron, manganese, molybdenum, nickel, selenium, silver, uranium, vanadium |
| Common ion concentrations (total) | Sulfate, total alkalinity, bicarbonate alkalinity, calcium, magnesium, sodium, potassium, chloride, hardness |
| Other physical properties | Water temperature, pH, specific conductivity |

2.4.4 Macroinvertebrates

Macroinvertebrate samples will be analyzed for the array of metrics that are listed in Table 2-8. From those metrics, three bioindices of macroinvertebrate biointegrity will be calculated: the Bollman Index [Bollman, 1998], the Hilsenhoff Biotic Index [Hilsenhoff, 1988], and the Metals Tolerance Index [McGuire, 2008]. Based on project precedent, the Bollman Index will be used as the reference value for SSTOU macroinvertebrate biointegrity [DEQ and NRDP, 2007].

Table 2-8. Macroinvertebrate Community Metrics That Will Be Used to Evaluate the Biological Integrity of Silver Bow Creek [Barbour et al., 1999]

| Metric | Definition | Purpose | Expected Response to Environmental Disturbance |
|--------------------------------|--|--|---|
| EPT Richness | Taxa count of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) | Reflect community diversity and may be an indicator of metals, silt, or temperature sensitivity | — |
| Number of Sensitive Taxa | Taxa count of organisms considered to be sensitive to disturbance | May indicate environmental stress from metals, silt, temperature, or habitat disturbance | — |
| Percent Tolerant | Proportion of disturbance tolerant organisms | May indicate overall stress to the aquatic community | + |
| Taxa Richness | Taxa count | May reflect overall diversity and habitat complexity | — |
| Percent Dominant | Proportion of most abundant species to all species | May reflect overall diversity; dominance of a taxa with specific types of tolerance to disturbance may identify the type and degree of disturbance | + |
| Percent Filterers | Proportion FPOM filtering organisms | May reflect degree of nutrient enrichment and other environmental stress | — |
| Percent Collectors | Proportion of FPOM collecting organisms | Abundance of collectors may reflect nutrient pollution, lack of riparian vegetation, or a limitation of a particular food source | — |
| Percent Scrapers and Shredders | Proportion of periphyton grazing specialist organisms (grazers) or organisms specialized in consuming detritus (shredders) or CPOM | May indicate sensitivity to some kinds of disturbances, or limitation/unsuitability of some food sources (e.g., diatoms or FPOM) | + |
| Percent Hydropsychidae | Proportion of caddisflies composed of the sub-family Hydropsychidae | May indicate nutrient enrichment | + |

FPOM = fine particle organic matter.

CPOM = coarse particulate organic matter.

2.4.5 Periphyton

Periphyton samples will be analyzed for the array of metrics listed in Table 2-9 and to assess “diatom increaser” metrics as described by Teply [2010].

Table 2-9. Periphyton Community Metrics That Will Be Used to Evaluate the Biological Integrity of Silver Bow Creek

| Metric | Reference | Biological Integrity | | | |
|-------------------------|-------------------------|----------------------|-------|-------|-----------|
| | | Poor | Fair | Good | Excellent |
| Species Richness | Bahls [1979; 1993] | <10 | 10–20 | 20–30 | >30 |
| Shannon Diversity Index | Bahls [1979] | <1 | 1–2 | 2–3 | >3 |
| Pollution Index | Bahls [1993] | <1.5 | 1.5–2 | 2–2.5 | >2.5 |
| Siltation Index | Bahls [1993] | >60 | 40–60 | 20–40 | <20 |
| Disturbance Index | Barbour et al. [1999] | >75 | 50–75 | 25–50 | <25 |
| % Dominant Species | Barbour et al. [1999] | >75 | 50–75 | 25–50 | <25 |
| % Abnormal Cells | McFarland et al. [1997] | >10 | 3–10 | 0–3 | 0 |

2.4.6 Fish

Fish-monitoring parameters will be described by MFWP.

2.4.7 Geomorphology

At each long-term sample site that is monitored for geomorphology, a longitudinal stream reach of approximately 1,000 feet will be established. Within each reach, channel cross sections will be established every 100 feet. At each channel cross section within a sample reach, the metrics in Table 2-10 will be monitored, and for each reach, the metrics in Table 2-11 will be summarized. Generally, geomorphology monitoring metrics and descriptors were adapted from the USEPA EMAP protocols for physical habitat characterization [Kaufmann, 2001].

Table 2-10. Monitoring Metrics That Will Be Used to Evaluate Stream Geomorphology at Each Channel Cross Section for Streamside Tailings Operable Unit Monitoring Sites

| Metric | Description | Purpose |
|-------------------------------------|---|--|
| Pebble Count | Cumulative pebble count conducted to represent the entire reach with 40 pebbles sampled at each cross section | Characterize bed sediment size composition |
| Pool Spacing | Distance between pools and riffle crests normalized to mean channel width | Assess pool frequency |
| Radius Curvature-Width Ratio (Rc/W) | Ratio of the radius of a circle drawn through a meander to bankfull channel width at that meander | Assess meander shape |
| Sinuosity | Ratio of channel-valley length | Assess channel planform |
| Channel Slope | Ratio of vertical drop to channel length | Assess channel gradient |
| Bankfull Width | Channel width from lowest bankfull indicator | Assess channel dimensions |
| Bankfull Depth | Channel depth from lowest bankfull indicator | Assess channel dimensions |
| Width-Depth Ratio | Ratio of channel width to mean depth | Assess channel dimensions |

Table 2-11. Monitoring Metrics That Will Be Used to Evaluate Stream Geomorphology in Each Stream Reach for Streamside Tailings Operable Unit Monitoring Sites

| Category | Metric | Description |
|--------------------------------|-------------------------------------|---|
| Channel Morphology | % Pools | Reach level percentages of each channel unit class based on observations at 10-foot intervals during thalweg profile measurements. |
| | % Riffles | |
| | % Runs | |
| Channel Cross Section | Mean width to depth ratio | Measures relationship of water surface area to volume. Important for thermal effects and the ability of the stream to move its banks and transport sediment. |
| Substrate Size and Composition | % fines (<0.06 mm) | Calculation of reach level percentages of particles in each size class for pebble counts conducted along transects. Important for stream development of proper stream geomorphology and spawning habitat. |
| | % sand (0.06–2 mm) | |
| | % fine gravel (2–16 mm) | |
| | % coarse gravel (1.6–6.4 cm) | |
| | % cobble (6.4–25 cm) | |
| | % boulder (0.25–4 m) | |
| Cover | % wood coverage | Calculation of whole reach averages, based on cover or presence estimates at the 10 transects. |
| | % overhanging vegetation | |
| | % undercut banks | |
| Riparian Vegetation | % coverage overstory (> 5 m tall) | Calculation of reach level means for riparian vegetation cover classes. |
| | % coverage understory (0.5–5m tall) | |
| | % coverage groundcover (> 5m tall) | |

As of 2017, field methods for pebble counts were altered by increasing the sample size. While count methods will remain the same, the sample size was increased from 5 pebbles sampled/transect as recommended by Kaufmann [2001] to 40 pebbles sampled/transect. We chose to increase the sample size to 440 pebbles sampled/reach (i.e., 40 pebbles sampled/transect at 11 transects) to improve the sampling precision, as recommended by Bunte and Abt [2001].

2.4.8 Vegetation, Soils, Birds, and Small Mammals

Vegetation, soil, bird, and small mammal monitoring parameters will be described by Bighorn Environmental Sciences.

2.5 SAMPLING METHODS

Field sampling procedures for surface water, instream sediment, groundwater, and vadose zone water will be in accordance with DEQ [2012a] and will generally follow “clean hands/dirty hands” procedures to minimize sample contamination as described in USGS [2006]. We will

deviate from the USGS [2006] protocols to minimize sample contamination³ in two regards by not collecting samples sequentially from the least to greatest potential for contamination and processing samples outside of sampling vehicles, rather than within an enclosed space. Unless requested to do so by DEQ project managers, we will not follow all of the “clean hands/dirty hands” protocols of Method 1669 [USEPA, 1996] or the low-level (i.e., part-per-trillion) protocols of the USGS to minimize sample contamination [Lewis and Brigham, 2004].

Surface water, instream sediment, groundwater, and vadose zone water field sampling methods will also comply with Clark Fork River Superfund Site Investigations Standard Operating Procedures (SOPs) that are described by the USEPA et al. [1992]. General SOPs from USEPA et al. [1992] that will be adhered to during for sample collection, documentation, and handling for each of those media will include the following:

- G-4 (field documentation and photographs)
- G-5 (sample packaging and shipping)
- G-6 (field quality control)
- G-7 (sample custody)
- G-8 (decontamination procedures for soil and water)
- HG-1 (sample site selection)
- HG-3 (sample container preparation)
- HG-4 (sample preservation and handling).

In addition, surface water, groundwater, and vadose zone water sampling will follow SOPs for measuring physical properties of water including the following:

- HG-8 (measurement of acidity, oxidation-reduction potential, and dissolved oxygen concentration)
- HG-10 (measurement of turbidity).

All sampling meters will be calibrated and maintained according to the manufacturer’s recommendations.

2.5.1 Surface Water

Surface water sampling will follow the identified general SOPs. Composited surface water samples will be collected using the width- and depth-integration approach according to methods that were described in USGS [2006]. In addition, surface water sampling will adhere to the following specific SOPs from the USEPA et al. [1992] pertaining to sample collection and handling methods for surface waters:

- HG-2 (composite sample collection)
- SW-1 (collection of samples for analysis of metal concentrations)

³ Described in Section 4.0.2 of USGS [2006].

- SW-5 (collection of samples for analysis of total suspended solid concentrations)
- SW-6 (measurement of stream flows).

2.5.2 Instream Sediment

Instream sediment sampling will follow the identified general SOPs (Section 2.5). In addition, sample collection methods for instream sediment will follow SOPs approved by DEQ [2012a]. As required by the SSTOU ROD, COC concentrations for instream sediment samples will be analyzed in fractions of three sizes: <0.065 mm, 0.065–1 mm, and 1–2 mm [DEQ and USEPA, 1995].

2.5.3 Groundwater and Vadose Zone Water

Groundwater and vadose zone water sampling will follow the identified general SOPs. Monitoring well and piezometer construction, maintenance, and sampling methods for groundwater and vadose zone water will adhere to the following specific SOPs from the USEPA et al. [1992]:

- GW-1 (groundwater sampling for inorganics)
- GW-3 (monitoring well design and construction)
- GW-4 (well development)
- GW-5 (measurement of water elevation, floating product thickness, and determination of well casing volume)
- GW-7 (single well/piezometer slug test)
- GW-8 (continuous groundwater level monitoring)
- GW-9 (groundwater sampling for organics).

Dedicated, or disposable, well bailers may be used in low-yield wells where installing a submersible pump is impractical. The decontamination procedures that are described in Section G-8 of USEPA et al. [1992] will not be implemented when disposable well bailers are used.

2.5.4 Macroinvertebrates

Macroinvertebrate sample collection and processing will follow SOPs approved by DEQ [DEQ, 2012b]. Samples will be collected from riffle habitat using the “travelling kick net” method [Snook, 2002] and a D-frame dipnet with 500 µm mesh. Kick-net sampling will extend from one stream margin and progress upstream and diagonally across the riffle to the other side of the stream. From non-riffle habitat types (e.g., fine sediment deposition areas, undercut banks, or instream wood), macroinvertebrates will also be collected using the jab technique. Stone, wood, and other structures collected in the sample will be rinsed in the net to remove macroinvertebrates and discarded. The samples will be transferred to jars, labeled, and preserved with 95 percent ethanol. The approximate surface area of stream substrate that is disturbed at each sample site will be recorded, and site photographs will be taken,

2.5.5 Periphyton

Periphyton samples will be collected according to DEQ SOPs [DEQ, 2011]. At each site, a single composite sample will be collected from the variety of available substrates in proportion to the availability of those substrates. Sample collection will follow the method identified as “PERI-1” [DEQ, 2011].

2.5.6 Fish

Field-sampling methods for fish monitoring will be described by MFWP and DEQ.

2.5.7 Geomorphology

At each geomorphic monitoring site, sample reaches that will extend from the staff gage (colocated with each monitoring site) to approximately 1,000 feet downstream will be established. Lateral channel cross-sections, which are arranged perpendicular to the stream flow direction, will be identified approximately every 100 feet within the sample reach. To identify cross-sections, markers (i.e., flags) will be placed along the left bank at 100-foot intervals. Longitudinal channel length will be measured along the left bank using a handheld tape.

A longitudinal profile of the stream thalweg will be surveyed throughout each stream reach. The spacing, frequency, and distribution of channel unit habitat types (i.e., riffles, runs, and pools) that are defined by Kaufmann [2001] will be identified in each reach. Survey data and recent aerial photography will be used to assess channel planform (i.e., radius of channel curvature, meander length, and overall sinuosity). All planform and cross-section surveys will be completed using a survey-grade global positioning system (GPS) that is accurate within 2 inches. Physical habitat assessments will be conducted after methods that were developed by the USEPA [Kaufmann, 2001].

2.5.8 Vegetation, Soils, Birds, and Small Mammals

Vegetation, soil, bird, and small mammal sampling methods will be described by Bighorn Environmental Sciences.

2.6 LABORATORY METHODS

2.6.1 Surface Water, Groundwater, and Vadose Zone Water

Analytes, methods, and reporting limits for water (i.e., surface, ground, and vadose zone) samples collected in the SSTOU are outlined in Table 2-12.

Table 2-12. Analytes, Methods, and Reporting Limits for Water Sampling in the Streamside Tailings Operable Unit (Page 1 of 2)

| Analyte | Requested Method | Requested Reporting Limit (mg/L) ^(a) | Holding Time (days) | Bottle | Preservative |
|---|------------------|---|---------------------|-------------|--|
| Water Samples – Physical Properties and Inorganics | | | | | |
| Solids, Total Suspended (at 105°C) | A 2540 D | 1 | 7 | 1 L HDPE | 4 ± 2°C |
| Alkalinity, Total (as CaCO ₃) | A 2320 B | 4 | 14 | 500 mL HDPE | |
| Alkalinity, Bicarbonate (as HCO ₃) | A 2320 B | 4 | 14 | | |
| Chloride | USEPA 300.0 | 1 | 28 | | |
| Sulfate | USEPA 300.0 | 1 | 28 | | |
| Hardness (as CaCO ₃) | A 2340 B | 1 | 180 | | |
| Water Samples – Nutrients | | | | | |
| Nitrogen, Ammonia (as N) | USEPA 350.1 | 0.05 | 28 | 250 mL HDPE | 4 ± 2°C |
| Nitrogen, Nitrate-Nitrite (as N) | USEPA 353.2 | 0.02 | | | H ₂ SO ₄ to pH <2, 4 ± 2°C |
| Nitrogen, Total | A 4500 N-C | 0.05 | 30 | | 4 ± 2 C |
| Phosphorus, Total | USEPA 365.1 | 0.003 | 28 | | H ₂ SO ₄ to pH <2, 4 ± 2°C |
| Water Samples – Dissolved Metals (0.45 µm filtered) | | | | | |
| Aluminum | USEPA 200.8 | 0.009 | 180 | 250 mL HDPE | HNO ₃ to pH <2 |
| Antimony | USEPA 200.8 | 0.0005 | | | |
| Arsenic | USEPA 200.8 | 0.001 | | | |
| Barium | USEPA 200.8 | 0.003 | | | |
| Beryllium | USEPA 200.8 | 0.0008 | | | |
| Boron | USEPA 200.8 | 0.1 | | | |
| Cadmium | USEPA 200.8 | 0.00003 | | | |
| Calcium | USEPA 200.8 | 1 | | | |
| Chromium | USEPA 200.8 | 0.01 | | | |
| Cobalt | USEPA 200.8 | 0.01 | | | |
| Copper | USEPA 200.8 | 0.001 | | | |
| Iron | USEPA 200.8 | 0.02 | | | |
| Lead | USEPA 200.8 | 0.0003 | | | |
| Magnesium | USEPA 200.8 | 1 | | | |
| Manganese | USEPA 200.8 | 0.001 | | | |
| Molybdenum | USEPA 200.8 | 0.005 | | | |
| Nickel | USEPA 200.8 | 0.002 | | | |
| Potassium | USEPA 200.8 | 1 | | | |
| Selenium | USEPA 200.8 | 0.001 | | | |
| Silver | USEPA 200.8 | 0.0002 | | | |

Table 2-12. Analytes, Methods, and Reporting Limits for Water Sampling in the Streamside Tailings Operable Unit (Page 2 of 2)

| Analyte | Requested Method | Requested Reporting Limit (mg/L) ^(a) | Holding Time (days) | Bottle | Preservative |
|---|------------------|---|---------------------|-------------|---------------------------|
| Water Samples – Dissolved Metals (0.45 µm filtered) (Continued) | | | | | |
| Sodium | USEPA 200.8 | 1 | | | |
| Uranium | USEPA 200.8 | 0.0002 | | | |
| Vanadium | USEPA 200.8 | 0.1 | | | |
| Zinc | USEPA 200.8 | 0.008 | | | |
| Mercury | USEPA 245.1 | 0.000005 | 28 | | |
| Water Samples – Total Recoverable Metals | | | | | |
| Total Recoverable Metals Digestion | USEPA 200.2 | — | — | — | — |
| Aluminum | USEPA 200.8 | 0.009 | 180 | 250 mL HDPE | HNO ₃ to pH <2 |
| Antimony | USEPA 200.8 | 0.0005 | | | |
| Arsenic | USEPA 200.8 | 0.001 | | | |
| Barium | USEPA 200.8 | 0.003 | | | |
| Beryllium | USEPA 200.8 | 0.0008 | | | |
| Boron | USEPA 200.8 | 0.1 | | | |
| Cadmium | USEPA 200.8 | 0.00003 | | | |
| Calcium | USEPA 200.8 | 1 | | | |
| Chromium | USEPA 200.8 | 0.01 | | | |
| Cobalt | USEPA 200.8 | 0.01 | | | |
| Copper | USEPA 200.8 | 0.001 | | | |
| Iron | USEPA 200.8 | 0.02 | | | |
| Lead | USEPA 200.8 | 0.0003 | | | |
| Magnesium | USEPA 200.8 | 1 | | | |
| Manganese | USEPA 200.8 | 0.001 | | | |
| Mercury | USEPA 245.1 | 0.000005 | 28 | | |
| Molybdenum | USEPA 200.8 | 0.005 | 180 | | |
| Nickel | USEPA 200.8 | 0.002 | | | |
| Potassium | USEPA 200.8 | 1 | | | |
| Selenium | USEPA 200.8 | 0.001 | | | |
| Silver | USEPA 200.8 | 0.0002 | | | |
| Sodium | USEPA 200.8 | 1 | | | |
| Uranium | USEPA 200.8 | 0.0002 | | | |
| Vanadium | USEPA 200.8 | 0.1 | | | |
| Zinc | USEPA 200.8 | 0.008 | | | |

(a) Requested reporting limits are either the required reporting limit from DEQ [2017] or DEQ [2014] (for nutrients) or the lowest reporting limit previously provided by the analytical laboratory, depending on which limit is lower.

L = liter.

mL = milliliter.

°C = degrees Celsius.

2.6.2 Instream Sediment

Analytes, methods, and reporting limits for instream sediment samples collected in the SSTOU are outlined in Table 2-13.

Table 2-13. Analytes, Methods, and Reporting Limits for Instream Sediment Sampling in the Streamside Tailings Operable Unit

| Analyte | Requested Method | Requested Reporting Limit (mg/kg-DW) ^(a) | Holding Time (days) | Bottle | Preservative |
|------------------------|------------------|---|---------------------|--------------------------------------|---|
| Total Metals Digestion | USEPA 3050 | — | — | — | — |
| Aluminum | SW 6010B | 5 | 180 | 1,000 mL clear glass wide mouth jars | 4 ± 2°C during shipment; – 15°C in laboratory |
| Antimony | SW 6020 | 5 | | | |
| Arsenic | SW 6010B | 5 | | | |
| Barium | SW 6010B | 5 | | | |
| Beryllium | SW 6010B | 5 | | | |
| Boron | SW 6010B | 5 | | | |
| Cadmium | SW 6010B | 0.2 | | | |
| Chromium | SW 6010B | 5 | | | |
| Cobalt | SW 6020 | 5 | | | |
| Copper | SW 6010B | 5 | | | |
| Iron | SW 6010B | 5 | | | |
| Lead | SW 6010B | 5 | | | |
| Manganese | SW 6010B | 5 | | | |
| Mercury | SW 7471B | 0.10 | | | |
| Molybdenum | SW 6020 | 5 | | | |
| Nickel | SW 6010B | 5 | | | |
| Selenium | SW 6020 | 5 | | | |
| Silver | SW 6020 | 5 | | | |
| Uranium | SW 6020 | 5 | | | |
| Vanadium | SW 6010B | 1 | | | |
| Zinc | SW 6010B | 5 | | | |

(a) Requested reporting limits are based on the lowest reporting limit previously provided by the analytical laboratory in 2014.

L = liter.

mL = milliliter.

°C = degrees Celsius.

2.6.3 Macroinvertebrates

Subsamples of a minimum of 500 organisms will be obtained using methods that are consistent with DEQ SOP [DEQ, 2012b]. To comply with DEQ SOP, Caton subsampling devices [Caton, 1991], which are divided into 30 grids (each approximately 6 centimeters [cm] by 6 cm) will be used. Each individual sample will be thoroughly mixed in its jar, poured out, and evenly spread into the Caton tray; the individual grids will be randomly selected. The contents of each grid will be examined under stereoscopic microscopes using 10–30 times magnification. All aquatic invertebrates from each selected grid will be sorted from the substrate and placed in 80 percent ethanol for subsequent identification. Grid selection, examination, and sorting will continue until at least 500 organisms are sorted. The final grid will be completely sorted for all organisms. All unsorted sample fractions will be retained and stored at the laboratory for 1 year.

Organisms will be individually examined by Society for Freshwater Science-certified taxonomists with 10–80 times magnification, stereoscopic dissecting scopes (Leica S8E) and identified to the lowest practical level that is consistent with the DEQ SOP [DEQ, 2012b] data requirements by using appropriate published taxonomic references and keys. Identification, counts, life stages, and information about the condition of specimens will be entered directly by the taxonomists into Rhithron's proprietary data entry interface (EPIC Version 1.7). Organisms that cannot be identified to the taxonomic targets because of immaturity; poor condition; or lack of complete current, regionally applicable, published keys will be left at appropriate taxonomic levels that are coarser than those specified. To obtain accuracy in richness measures, these organisms will be designated as “not unique” if other specimens from the same group may be taken to target levels. Organisms designated as “unique” will be those that can be definitively distinguished from other organisms in the sample. Identified organisms will be preserved in 80 percent ethanol in labeled vials and archived at the Rhithron Associates, Inc. laboratory for 1 year.

Chironomidae and Oligochaeta will be morphotyped using 10–80 times magnification, stereoscopic dissecting microscopes (Leica S8E), and representative specimens will be slide mounted and examined at 200–1000 times magnification using an Olympus BX 51 or Leica DM1000 compound microscope. Slide-mounted organisms will be archived at the Rhithron laboratory for 1 year.

2.6.4 Periphyton

Periphyton samples will be preserved in Lugol's solution and thoroughly mixed by shaking in the laboratory. Permanent diatom slides will be prepared, and subsamples will be taken and treated with concentrated sulfuric acid and 30 percent hydrogen peroxide. Samples will be rinsed with distilled water to neutralize the samples, and subsample volumes will be adjusted to obtain adequate densities. Small amounts of each sample will be dried on 22-mm square coverslips. Coverslips will be mounted on slides with the Naphrax diatom mount. To ensure a high-quality mount for identification and to make replicates available for archives, three slide mounts will be

made from each sample. One of the replicates will be selected from each sample batch for identification. A diamond scribe mark will be made to define a transect line on the cover slip, and a minimum of 600 diatom valves will be identified along the transect mark. A Leica DM 2500 compound microscope, Nomarski contrast, and 1,000 times magnification will be used for identifications. Diatoms will be identified using standard taxonomic references and classified at the lowest taxonomic level that is practical.

For soft-bodied (i.e., nondiatom) algae samples, the raw periphyton sample will be manually homogenized and emptied into a porcelain evaporating dish. A small, random subsample of algal material will be pipetted with a disposable dropper onto a standard, glass microscope slide. Visible (macroscopic) algae will also be subsampled, in proportion to their estimated importance relative to the total volume of algal material in the sample and added to the liquid fraction on the slide. The wet mount will then be covered with a 22- × 30-mm cover slip.

Soft-bodied algae will be identified to genus using a DM2500 compound microscope under 200–400 times magnification. The relative abundance of each algal genus and of all diatom genera collectively at 200 times magnification (on average) will be estimated for comparative purposes according to the following system:

- R (rare): <1 cell per field of view
- C (common): 1 to <5 cells per field of view
- VC (very common): 5 to <25 cells per field of view
- A (abundant): >25 cells per field of view (but within practical count limits)
- VA (very abundant): cells per field too numerous to count.

Soft-bodied genera (and the diatom component) will also be ranked according to their estimated contribution to the total algal biovolume present in the sample.

2.7 QUALITY ASSURANCE AND QUALITY CONTROL PROCEDURES

The project QAPP describes QA/QC procedures for surface water, instream sediment, groundwater, vadose zone water, macroinvertebrate, periphyton, and geomorphology sampling and analysis in the SSTOU [RESPEC, 2014b]. No amendments were made to QA/QC protocols in the project QAPP in 2018. Therefore, the QAPP document from 2014 [RESPEC, 2014b] will describe project QA/QC procedures for surface water, instream sediment, groundwater, vadose zone water, macroinvertebrate, and periphyton sampling and analysis in 2018. Protocols for data QA/QC for fish monitoring will be described by MFWP, and protocols for data QA/QC for vegetation, soil, bird, and small mammal monitoring will be described by Bighorn Environmental Sciences.

2.8 SCHEDULE FOR PROJECT COMPLETION

Sample collection will be completed by December 31, 2018. A draft report that describes the data collected will be completed by June 1, 2019.

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APPENDIX A

SUMMARY OF ANNUAL CHANGES TO THE MONITORING PROGRAM

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SUMMARY OF ANNUAL CHANGES TO THE MONITORING PROGRAM

A.1 2005

- Site SS-08 (Silver Bow Creek at Rocker) was added to surface water, sediment, and aquatic biota monitoring networks.
- Site SS-10 (Silver Bow Creek at Sand Creek) was replaced by Sites SS-10A (Silver Bow Creek above Sand Creek) and SS-10B (Silver Bow Creek below Sand Creek) to assess the influence of Sand Creek for surface water, sediment, and aquatic biota.
- Site SS-13 (Silver Bow Creek at Browns Gulch) was replaced by Sites SS-11C (Silver Bow Creek above Browns Gulch) and SS-11D (Silver Bow Creek below Browns Gulch) to assess the influence of Browns Gulch for surface water, sediment, and aquatic biota.
- Manganese and bicarbonate concentrations were added to the analyte list for surface water, groundwater, and vadose zone water and ammonia concentrations were added to the analyte list for surface water monitoring.
- Modifications to soil, aquatic biota, and vegetation monitoring were made.

A.2 2006

- Site SS-06G (Silver Bow Creek above WWTP) was added to surface water, sediment, and aquatic biota monitoring networks to evaluate the influence of the Butte Wastewater Treatment Plant (WWTP) discharge.

A.3 2007

- To assess the influence of German Gulch, three sites were added to surface water, sediment, and aquatic biota monitoring networks in Subarea 3: SS-15A (Silver Bow Creek above German Gulch), SS-15B (Silver Bow Creek below German Gulch), and Station SS-15G (German Gulch).

A.4 2008

- No changes were made to monitoring methods in 2008.

A.5 2009

- To assess conditions upstream from the SSTOU, two sites were added to surface water, sediment, and aquatic biota monitoring upstream: SS-01 (Blacktail Creek at Father Sheehan Park) and SS-06A (Silver Bow Creek at the Butte Reduction Works). SS-01 was mistakenly labeled as SS-05A in the 2009 monitoring plan.
- Site SS-14 (Silver Bow Creek at Miles Crossing) was added to surface water, sediment, and aquatic biota monitoring networks after remediation in that reach.

A.6 2010

- Water samples were filtered in the field rather than in the laboratory to analyze dissolved constituents.
- The analytical laboratory sediment samples changed. Before 2010, all sediment samples were analyzed and reported on a dry weight (DW) basis. From 2010 to 2013, sediment samples were analyzed and reported on the wet weight (WW) basis because of concern about the potential volatilization of mercury during the drying phase of the analytical process. In 2014, sediment samples were analyzed on the WW and DW basis.

A.7 2011

- Surface water samples were collected using width- and depth-integration methods [U.S. Geological Survey, 2006] as opposed to point samples (i.e., grab samples) [U.S. Environmental Protection Agency et al., 1992] to provide more representative samples at sites immediately downstream from tributary and effluent discharges.
- Sediment samples were collected using the Montana Department of Environmental Quality (DEQ) standard protocol [DEQ, 2012a] rather than the grab sample method [U.S. Environmental Protection Agency et al., 1992] to reduce variability among field duplicates.

A.8 2012

- Site SS-06A (Silver Bow Creek at Butte Reduction Works) was replaced by Site SS-05A (Silver Bow Creek above Butte Reduction Works) for surface water, sediment, and aquatic biota monitoring because local beaver activity made sampling difficult at Site SS-06A.

A.9 2013

- Site SS-13 (Silver Bow Creek in Reach L) was added to the surface water, sediment, and aquatic biota monitoring network approximately midway between Sites SS-11D and SS-14 to comply with requirements in the SSTOU ROD [DEQ and U.S. Environmental Protection Agency, 1995].
- Site SS-16B (Silver Bow Creek in Reach P near Fairmont) was added to the surface water, sediment, and aquatic biota monitoring networks. Site SS-16B was established slightly downstream from Site SS-16 and identified in the SSTOU ROD [DEQ and U.S. Environmental Protection Agency, 1995] to allow several small tributaries that are located immediately upstream to mix.
- Nine groundwater monitoring wells were established in three clusters (three wells per cluster) near the towns of Fairmont, Crackerville, and Opportunity (Stuart townsite). At each cluster, two floodplain monitoring wells were established on each side of the stream and one background well was established immediately outside the floodplain.

A.10 2014

- Metal concentrations in sediment samples were analyzed on the WW and DW basis.
- Surface water, instream sediment, and aquatic biota was monitored at SS-19 (Silver Bow Creek at Frontage Road) to comply with requirements in the SSTOU ROD [DEQ and U.S. Environmental Protection Agency, 1995].
- Three groundwater monitoring wells were established in a cluster (the Frontage Road cluster) near the surface water sample Site SS-19 (Silver Bow Creek at Frontage Road).
- Analytical reporting limits were lowered for some analytes so that all reporting limits were either as low as the required reporting limits of DEQ [2012b] or as low as previous project reporting limits.

A.11 2015

- Metal concentrations in sediment samples were analyzed only on the DW basis.
- Dissolved organic carbon and volatile suspended sediment concentrations were added to the suite of surface water monitoring parameters.

A.12 2016

- Two floodplain wells in the Colorado Tailings Cluster were discontinued and replaced because of damage from beaver activity and frost heaving. Replacement wells (GW-WG-SS and GW-WG-NS) were installed nearby.
- One sediment monitoring site was added to the monitoring network in Subarea 3: SS-15A-2 (Silver Bow Creek above German Gulch [Alternate Site]).
- Two sediment monitoring sites were added to the monitoring network upstream from the SSTOU: SS-04 (Blacktail Creek at Metro Storm Drain Confluence) and SLAG-01 (Silver Bow Creek in Slag Canyon). These sites were monitored for sediment in the fine fraction (<0.065 millimeters) and only for arsenic, copper, cadmium, lead, and zinc.

A.13 2017

- Surface water, sediment, and aquatic biological monitoring Site SS-10B (Silver Bow Creek below Sand Creek) was discontinued. Site SS-10B was originally intended to provide a paired site with Site SS-10A (Silver Bow Creek above Sand Creek). Monitoring since 2010 at those two sites demonstrated little difference in contaminant of concern (COC) concentrations in either surface water or sediment, which suggests that Sand Creek is not a substantial source of COCs. Moreover, Site SS-10B was located immediately upstream from a railroad trestle with support footings in the streambed. Those trestle footings frequently collected floating debris, which accumulated and created a damming effect in the stream channel at Site SS-10B. As a result, geomorphic channel conditions at Site SS-10B differed markedly from conditions at Site SS-10A that confounded comparisons between the two sites.
- Dissolved organic carbon and volatile suspended sediment concentrations were removed from the suite of surface water monitoring parameters.

A.14 2018

- Site SS-15A (Silver Bow Creek above German Gulch) will be discontinued and replaced by an alternate site (SS-15A-2), which was located approximately 150 meters upstream. This change will be made because Site SS-15A is not representative of the majority of the stream channel condition in Subarea 3 above German Gulch. Site SS-15A is located in a short (approximately 0.3 stream kilometers [km]), narrow, bedrock chute with residual tailings. This narrow chute was not remediated because of the low volume of floodplain tailings in that reach, tight working space, and poor access for heavy equipment. All other streambed and floodplain portions of Subarea 3 above German Gulch (approximately 6.5 stream km) were remediated.

- Laboratory analysis methods for macroinvertebrate samples will be updated from Bukantis [1998] to DEQ [2012b], which will require an increase in the number of macroinvertebrates subsampled in each sample from 300 to 500.

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